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A Mark–Recapture Study of Kuskokwim River Sockeye, Chum, and Coho Salmon, 2004

Annual Report for Project FIS 04-308
USFWS Office of Subsistence Management
Fisheries Information Services Division

by

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Alaska Department of Fish and Game **Divisions of Sport Fish and Commercial Fisheries**

Symbols and Abbreviations

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Weights and measures (metric)

centimeter	cm
deciliter	dL
gram	g
hectare	ha
kilogram	kg
kilometer	km
liter	L
meter	m
milliliter	mL
millimeter	mm

Weights and measures (English)

cubic feet per second	ft^3/s
foot	ft
gallon	gal
inch	in
mile	mi
nautical mile	nmi
ounce	oz
pound	lb
quart	qt
yard	yd

Time and temperature

day	d
degrees Celsius	°C
degrees Fahrenheit	°F
degrees kelvin	K
hour	h
minute	min
second	s

Physics and chemistry

all atomic symbols	
alternating current	AC
ampere	A
calorie	cal
direct current	DC
hertz	Hz
horsepower	hp
hydrogen ion activity (negative log of)	pH
parts per million	ppm
parts per thousand	ppt, ‰
volts	V
watts	W

General

Alaska Administrative Code	AAC
all commonly accepted abbreviations	e.g., Mr., Mrs., AM, PM, etc.
all commonly accepted professional titles	e.g., Dr., Ph.D., R.N., etc.
at	@
compass directions:	
east	E
north	N
south	S
west	W
copyright	©
corporate suffixes:	
Company	Co.
Corporation	Corp.
Incorporated	Inc.
Limited	Ltd.
District of Columbia	D.C.
et alii (and others)	et al.
et cetera (and so forth)	etc.
exempli gratia (for example)	e.g.
Federal Information Code	FIC
id est (that is)	i.e.
latitude or longitude	lat. or long.
monetary symbols (U.S.)	$, ¢
months (tables and figures): first three letters	Jan,...,Dec
registered trademark	®
trademark	™
United States (adjective)	U.S.
United States of America (noun)	USA
U.S.C.	United States Code
U.S. state	use two-letter abbreviations (e.g., AK, WA)

Measures (fisheries)

fork length	FL
mideye-to-fork	MEF
mideye-to-tail-fork	METF
standard length	SL
total length	TL

Mathematics, statistics

all standard mathematical signs, symbols and abbreviations	
alternate hypothesis	H_A
base of natural logarithm	*e*
catch per unit effort	CPUE
coefficient of variation	CV
common test statistics	(F, t, χ^2, etc.)
confidence interval	CI
correlation coefficient (multiple)	R
correlation coefficient (simple)	r
covariance	cov
degree (angular)	°
degrees of freedom	df
expected value	*E*
greater than	>
greater than or equal to	≥
harvest per unit effort	HPUE
less than	<
less than or equal to	≤
logarithm (natural)	ln
logarithm (base 10)	log
logarithm (specify base)	$\log_2$, etc.
minute (angular)	'
not significant	NS
null hypothesis	H_O
percent	%
probability	P
probability of a type I error (rejection of the null hypothesis when true)	α
probability of a type II error (acceptance of the null hypothesis when false)	β
second (angular)	"
standard deviation	SD
standard error	SE
variance	
population	Var
sample	var

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TABLE OF CONTENTS

Page

TABLE OF CONTENTS (Continued)

LIST OF TABLES

LIST OF FIGURES

LIST OF FIGURES (Continued)

LIST OF APPENDICES

ABSTRACT

Spaghetti tags were deployed on sockeye *Oncorhynchus nerka*, chum *O. keta*, and coho *O. kisutch* salmon caught in the mainstem Kuskokwim River and recovered upstream in the mainstem and at several tributaries to determine stock-specific run timing, stock-specific travel speed, and to estimate total coho salmon run abundance using a two-sample mark–recapture design. Fish were captured downstream of Lower Kalskag using fish wheels and drift gillnets, and then fitted with uniquely numbered spaghetti tags. Tags were then recovered, or at least observed, at five upstream tributary escapement projects (Takotna, Tatlawiksuk, Kogrukluk, and George River weirs, and Aniak River sonar). Recoveries were also made from fish wheels and gillnets operated in the mainstem Kuskokwim River below Aniak and from opportunistic voluntary tag returns. Tag deployment in 2004 included 1,885 sockeye, 5,276 chum, and 2,971 coho salmon. Tag recovery included 108 sockeye, 632 chum, and 81 coho salmon recaptured in the Kuskokwim River and 52 sockeye, 78 chum, and 115 coho salmon observed at upstream tributary projects. Overall, salmon run timing past Kalskag was earliest for stocks traveling to tributaries farthest upstream and progressively later for stocks traveling to less distant tributaries, which is consistent with findings from previous years. Average stock-specific travel speed for coho and chum salmon was greatest for salmon traveling farthest upstream, and progressively slower for fish traveling to less distant tributaries. Coho salmon abundance upstream from Lower Kalskag in 2004 was estimated to be 386,743 coho salmon (95% CI=303,995; 469,492) using the Darroch estimator.

Key words: Kuskokwim River, sockeye salmon, *Oncorhynchus nerka*, chum salmon, *O. keta*, coho salmon, *O. kisutch*, tagging, mark–recapture, abundance estimate, run timing, travel speed.

INTRODUCTION

Kuskokwim River salmon stocks have been challenging to manage because numerous stock assemblages among different species overlap in run timing and the drainage is large, remote, and geographically diverse. Although the river is the second largest in Alaska (Moody et al. 1986) and supports one of the largest and most important subsistence fisheries in the state (ADF&G 2001), research and management tools have been limited. A subsistence fishery occurs along nearly 1,174 river km (rkm) and includes approximately 1,011 households from 29 communities. Commercial fishing occurs in the lower 203 rkm of the river where 840 permits were issued under the state's limited entry program. Salmon spawn in over 28 navigable tributaries (Brown 1983) including the Kialik River, which is 3 km from the Kuskokwim River mouth to the uppermost headwaters approximately 1,548 rkm away (Whitmore et al. 2005).

Ideally, fishery managers have preseason knowledge of salmon run abundance and can accurately assess stock specific run strength and timing. From that knowledge they identify if there is a harvestable surplus above spawning requirements, provide for the priority use of subsistence fishers throughout the drainage, and allow any remaining surplus to be allocated to other fishers (sport, commercial, and personal use). The gauntlet nature of this fishery, the necessity to spread harvest opportunity over much of the river, and the potential of differential exploitation, especially between upper and lower river stocks, increases the challenge to sustain the fisheries for all users. Currently, fishery managers do not forecast run abundance, monitor actual abundance in season, or have sufficient knowledge of run timing differences among stocks in the mainstem Kuskokwim River to evaluate the need to selectively target or protect individual stocks. Decisions to open and close fisheries are based on catch per unit effort (CPUE) trends from a gillnet test fishery operated near Bethel, CPUE and catch trends from commercial and subsistence fisheries, and select tributary escapement counts (Whitmore et al. 2005). Escapement requirements according to the state's Policy for Statewide Salmon Escapement Goals (5 AAC 39.223) have been determined for 9 spawning locations for Chinook salmon *Oncorhynchus tshawytscha*, two spawning locations for chum salmon *O. keta*, and one spawning

location for coho salmon *O. kisutch* for the entire Kuskokwim River drainage (ADF&G 2004). No escapement requirements are currently in place for sockeye salmon *O. nerka*. Current escapement goals are ranges representing the 15th (or 25th) to 75th (or 85th) percentile of escapements observed for each system with the actual percentile chosen based on data contrast and assumed level of exploitation (Bue and Hasbrouck 2001). Since catch by stock is unknown, traditional spawner-recruit analyses are not possible for individual tributaries.

To meet the challenge of sustainable management of salmon fisheries in the Kuskokwim River, drainage-wide abundance and stock specific migratory timing is needed. Abundance estimates are needed preseason, inseason, and as representative of actual spawning abundance (i.e. total abundance minus total harvest equals spawning escapement). Drainage-wide abundance, when coupled with a drainage-wide escapement goal, would allow managers to identify a harvestable surplus. Stock specific migratory timing information is also needed to evaluate stock timing differences and to determine if stocks may be differentially harvested through time. Harvest strategies must be evaluated and exploitation rates calculated. A goal of sustainable management is to include escapement counts with adequate distribution throughout the drainage.

This project is a continuation of a project that began in 2001 (Kerkvliet and Hamazaki 2003; Kerkvliet et al. 2003, 2004). It was designed to provide additional information useful for managing the fisheries by using mark–recapture techniques in the Kuskokwim River, upstream from Kalskag, to estimate run timing of specific monitored stocks of sockeye, chum, and coho salmon, and to estimate total abundance of coho salmon. Fish wheels and drift gillnets were used near Lower Kalskag to capture adult salmon for marking. Marked fish were recovered upriver in the mainstem Kuskokwim near Aniak and tributary escapement projects (Figure 1). Use of uniquely numbered spaghetti tags provided information on migratory timing and travel speed in the mainstem for salmon stocks spawning in tributaries with escapement monitoring projects.

BACKGROUND

The following narrative reviews the background and history of Kuskokwim River sockeye, chum, and coho salmon mark–recapture/tagging experiments, current methods used to evaluate escapement, and the results and present funding status of the Kuskokwim River tagging project.

Targeted Species

Chum salmon is the second most important species in the commercial and subsistence harvest. Coho salmon is the most important commercial species (Burkey et al. 2001) and Chinook salmon is the most important subsistence species (Coffing et al. 2001). In 2000, Kuskokwim River chum salmon were listed as a stock of concern under the Policy for Management of Sustainable Salmon Fisheries (5 AAC 39.222) because of the chronic inability of managers to maintain expected harvest and escapements levels (Burkey et al. 2000). Commercial fishing for chum salmon had been closed since 1999 and a subsistence fishing schedule of 4 days per week was established in 2001. The stock of concern status for chum salmon was reaffirmed in 2004 (Bergstrom and Whitmore 2005). Runs have improved since 2001 and commercial fishing was allowed again in 2004. The United States Congress identified Kuskokwim River coho salmon in the fishery disasters declared in 1997 and 1998. Although sockeye salmon were not listed as a stock of concern, escapement levels for these species are virtually unknown and remain a concern to managers. Interest in sockeye salmon for commercial and subsistence use has

increased in recent times. In 2004, the Alaska Board of Fisheries approved a sockeye salmon guideline harvest limit of 0 to 50,000 fish (Whitmore et al. 2005).

Escapement Monitoring

Weirs are currently operated on 6 major tributaries of the Kuskokwim River to monitor salmon escapement and a sonar-counting project is operated on a seventh (Figure 1). A weir on the Kogrukluk River indexes the Holitna River stock, and has annual escapement data dating back to 1976 (Baxter *Unpublished*; Shelden et al. 2005). The Kogrukluk River weir is approximately 219 rkm upriver from the mouth of the Holitna River and 710 rkm from the mouth of the Kuskokwim River. Adult salmon take approximately 3 to 4 weeks to pass the weir from the mouth of the Kuskokwim River. The Kogrukluk River drainage is the only system with a weir escapement goal for chum, coho, and Chinook salmon; however, its value to managers for opening and closing fisheries is limited during the early portion of each run because of the protracted lag time between when this spawning stock travels through commercial and subsistence fisheries to when they pass the weir. Since the mid 1990s, five additional weirs were established to better quantify escapement and run strength. These weirs are located on the following tributaries: Kwethluk River (Roettiger et al. 2005), Tuluksak River (Zabkar et al. 2005), George River (Stewart et al. 2005), Tatlawiksuk River (Stewart and Molyneaux 2005), and Takotna River (Costello et al. 2005). A sonar project on the Aniak River is used to index chum salmon escapement during late June and July when this species dominates, and a sonar-based escapement goal has been established for chum salmon in the Aniak River (Sandall and Pfisterer 2006).

Recently, escapement monitoring projects using radiotelemetry techniques were established to study Chinook, chum, and coho salmon in the Holitna River drainage and Chinook salmon in the Kuskokwim River upstream from Kalskag. The radiotelemetry study for the Holitna was initiated in 2001 (Chythlook and Evenson 2003) to estimate Chinook, chum, and coho abundance and the percent monitored by the Kogrukluk weir. In 2003, coho salmon were eliminated from the study (Stroka and Brase 2004) and only Chinook and chum abundance was estimated. The project ended with the estimation of abundance of Chinook and chum salmon in 2004 (Stroka and Reed 2005). A project to estimate abundance of Chinook salmon in the Kuskokwim River, upstream of Kalskag, began in 2002 (Stuby 2003, 2004).

Stock-specific Run Timing and Total Run Abundance Estimates

For many years researchers and managers recognized the importance of stock-specific run timing information and total run abundance estimates for adult salmon returning to spawn. Numerous tagging projects have been conducted on large river systems such as the Kuskokwim and Yukon rivers where gauging run strength is complex. Early mainstem tagging projects on the Kuskokwim and Yukon rivers were not designed to estimate abundance and had limited success. In the 1960s, tagging studies were conducted on the Kuskokwim River (ADF&G 1961a, 1962, 1966) and the Yukon River (ADF&G 1961b; Lebida 1969; Regnart 1962, 1964). Distance traveled by tagged fish and the number of days between release and recapture were calculated from these data, but stock-specific information was lacking. The primary deficiencies of these studies were the inability to tag adequate numbers of fish and the absence of tributary projects to recover tags. No stock-specific mark and recovery data were available. The greatest number of tags deployed during this period was 362 Chinook salmon tags on the Kuskokwim River (ADF&G 1966).

More recently, researchers tried to characterize run timing differences among chum salmon stocks in the Kuskokwim River. In 1995, the Bering Sea Fishermen's Association funded a radiotelemetry study for chum salmon (Parker and Howard 1995) with the objective of identifying temporal differences in stock-specific run timing as they passed through the lower river commercial fishing districts. The project fell short in reaching this objective because, among other factors, too few chum salmon were tagged and receiver stations failed.

Estimating stock specific run timing has been successfully demonstrated elsewhere on returning adult Chinook and sockeye salmon. In the Copper River, individual stocks of Chinook salmon were found to have different mean dates of passage that maintained over the study (Savereide 2004). From 1996 to 2001, Keefer et al. (2004) were able to differentiate between 38 spatially separated stocks of Chinook salmon in the Columbia River Basin by median dates of passage using radio tags. Stock specific run timing was also investigated for sockeye salmon from the Fraiser River system (Killick 1955), Bristol Bay (Rowse 1985; Jensen and Mathisen 1987), and the Copper River drainage (Merritt and Roberson 1986). Consistent differences in timing and migration rate among sockeye stocks of the Frasier River have been observed from the location of fisheries to the time of spawning (Killick 1955). In contrast, such chronological separations have not been as clear in Bristol Bay sockeye runs (Groot and Margois 1991). Merritt and Roberson (1986) found earlier migrating sockeye stocks demonstrated a greater consistency of timing between years than later migrating stocks.

Improvements in tagging techniques, fish handling and capture gear, coupled with advances in estimation modeling and model testing (Schwarz and Seber 1999) allow researchers to effectively estimate the population size of adult salmon migrating up large rivers. From 1982 to 1985 on the Susitna River, Barrett et al. (1984a, 1984b) demonstrated that large numbers of adult salmon could be tagged and recovered using fish wheels, supplemented by tributary monitoring for mark to unmarked data. Population estimates were calculated for Chinook salmon in the lower Yukon River (Spencer et al. 2002) and the Yukon River at the border with Canada (Johnson et al. 2002), Keta River (Brownlee et al. 1999), Kenai River (Hammarstrom and Hasbrouck 1998, 1999), Taku River (McPherson et al. 1998), Stikine River (Pahlke and Etherton 2000), Copper River (Evanson and Wuttig 2000), and recently the Holitna River (Wuttig and Evenson 2002; Chythlook and Evenson 2003; Stroka and Brase 2004) and Kuskokwim River above Kalskag (Stuby 2003, 2004). Chum salmon abundance was estimated for the upper Tanana River (Cappiello and Bruden 1997; Cappiello and Bromaghin 1997; Cleary and Bruden 2000; Cleary and Hamazaki 2002), the upper Yukon River (Underwood et al. 1998), and the Yukon River at the border with Canada (JTC 2002). These Yukon River projects provide inseason estimates of chum salmon and use fish wheel release and recovery methods. Coho salmon abundance has been estimated using mark–recapture techniques on the Kenai River (Carlon 2000), Chilkat River (Ericksen 1999), Steep Creek (Jones III and McPherson 1997), Unuk River (Jones III et al. 2001), and Holitna River (Wuttig and Evenson 2002; Chythlook and Evenson 2003; Stroka and Brase 2004). This list is not meant to be exhaustive but reflective of the successful application of the technique in large rivers in Alaska.

Kuskokwim River Salmon Mark–recapture Project

Following declaration of the 1997 and 1998 fisheries as disasters in Bristol Bay, and in the Kuskokwim and Yukon rivers, Congress appropriated $7 million to develop a disaster research and prevention plan. The resulting Western Alaska Salmon Fisheries Disaster Mitigation Research Plan (WASFDP) recognized the critical importance of healthy western Alaska salmon

runs to area residents (ADF&G 1999). Chum, Chinook, and coho salmon of the Kuskokwim River were all considered vitally important. Through the WASFDP grant, $495,000 was awarded to the Alaska Department of Fish and Game (ADF&G) to specifically estimate abundance and migratory timing characteristics of Kuskokwim River coho salmon using mark–recapture techniques.

The WASFDP was revised in 2001 and redirected Kuskokwim River mainstem sonar project funds (Eggers 2001) toward additional mark–recapture studies for Chinook, chum, and sockeye salmon. These species were included because of their importance to subsistence and commercial fishers, their recent declines in abundance, and the shortage of information available to fisheries managers. ADF&G Division of Sport Fish has been responsible for estimating the abundance of Chinook salmon in the mainstem, and the Division of Commercial Fisheries has been responsible for chum, coho, and sockeye salmon. In 2002, the state's general funds designated for the Kuskokwim River sonar were redirected to support the coho, sockeye, and chum salmon mark–recapture project. In June of 2003, funding from the WASFD grant ended, but replacement funds were awarded through the Arctic-Yukon-Kuskokwim Sustainable Salmon Initiative (AYK-SSI) and United States Fish and Wildlife Service (USFWS) Office of Subsistence Management (OSM). In 2004, funds awarded through AYK-SSI were discontinued, but a multi-year grant was awarded through the USFWS OSM Fisheries Resource Monitoring Program (project FIS 04-308).

The first year of operation (2001) assessed the feasibility of the project and focused on coho salmon. ADF&G and the Kuskokwim Native Association worked together to design and construct 4 fish wheels, select fish wheel sites, select a field campsite near Aniak, and organize logistics for tag recovery. In this feasibility year, the investigators successfully tested various fish wheel sites, configurations, and gillnet drift locations (Kerkvliet and Hamazaki 2003). They investigated tag recovery methods at weir sites and conducted a tag recovery lottery. A coho salmon abundance estimate was not calculated. Run timing results using cumulative percentage of recovered coho salmon above the tagging sites suggested fish entering the river early enter tributaries further upstream than fish entering later. This result supported Traditional and Ecological Knowledge (TEK) from local residents. Differences in travel time were also detected from tag recoveries at escapement projects. A significant difference in travel speed was found between coho salmon tagged earlier, which traveled slower than those tagged later in the run.

In 2002 and 2003, the scope of the project increased to include sockeye and chum salmon (Kerkvliet et al. 2003, 2004). Low numbers of sockeye salmon captured and tagged led to the inability to recover adequate numbers of tagged salmon to estimate the population size in 2002. However, in 2003 enough sockeye salmon were sampled to produce a pooled estimate using the Peterson estimator. The sockeye salmon abundance upstream of Kalskag was 90,449 fish (95% CI=54,842, 126,056; SE=18,168).

Temporal differences in tag recovery were observed at the Aniak tag recovery site in 2002 and 2003 for chum and coho salmon using the Kalskag/Aniak data set. Through use of the Darroch estimator and data stratified through time an acceptable estimate was achieved. The population estimate of chum salmon upstream from Kalskag in 2002 was 675,659 (95% CI=559,564–791,755; SE=59,232) and in 2003 412,443 (95% CI=351,765–473,121; SE=30,958). The population estimate of coho salmon upstream from Kalskag in 2002 was 316,068 (95% CI=193,877–438,259; SE=62,342) and in 2003 was 849,494 (95% CI=654,182–1,044,806; SE=99,649).

From 2001 to 2003, stock-specific run timing results using cumulative percentages of tagged sockeye, chum, and coho salmon recovered at escapement projects indicated fish tagged earlier traveled to tributaries further upstream, and that fish tagged later in the season traveled to tributaries progressively farther down stream (Kerkvliet et al. 2003, 2004; Kerkvliet and Hamazaki 2003). This pattern was most prominent for chum salmon. Furthermore, from 2002 to 2003 data showed that chum and coho salmon traveling speed increased as distance from the tag site increased.

In addition to tagging sockeye, chum and coho salmon, the Kuskokwim River mark–recapture study served as a platform for other projects involved in research of Kuskokwim River fishes. A radiotelemetry study has been conducted on Chinook salmon by ADF&G, Division of Sport Fish, using drift gillnets with catches supplemented by fish wheel caught Chinook (Stuby 2004). Another study was conducted this year by ADF&G, Division of Commercial Fisheries, involving sampling chum salmon to determine the composition and run-timing of fall chum salmon passing by the fish wheels (Gilk et al. 2005). Also, whitefish *Coregonus* spp. were sampled by the USFWS from the fish wheels for age, sex, and length information; gonadosomatic indexing analysis as well as catch indexing and tag recovery (Harper and Wyatt *In prep*).

OBJECTIVES

The 2004 project was redesigned to address reduced funding from previous years. We chose to eliminate previous objectives to estimate abundance of sockeye and chum salmon. Past low sample sizes or violations of mark recapture assumptions made these species difficult to estimate. However, in 2004 we continued tagging sockeye and chum salmon to estimate stock-specific run timing and mean travel speed. The 2004 objectives were modified to provide managers a tool in making informed decisions toward sustainable fisheries management.

1. Estimate abundance of coho salmon in the Kuskokwim River upstream of Lower Kalskag (rkm 249), with a relative precision (coefficient of variation) of +/- 20% or less.
2. Estimate run timing of sockeye, chum, and coho salmon stocks tagged at the Lower Kalskag site using recaptures from upstream escapement projects.
3. Estimate mean travel speed of sockeye, chum, and coho salmon tagged at the Lower Kalskag site through recoveries at the upstream escapement projects.

METHODS

STUDY DESIGN

This study was designed to estimate run timing and mean travel speed of sockeye, chum, and coho salmon and to estimate the population size of coho salmon using mark–recapture methods. We had two opportunities to estimate abundance for coho salmon. The first mark–recapture opportunity was between marking at the Lower Kalskag site (249 rkm) and recovery at the Aniak site (294 rkm) on the Kuskokwim River (Figure 1; Table 1). The second opportunity for estimation was between marking at the Lower Kalskag tag site and recovery at upstream tributary escapement projects. The approximate rkm from the Lower Kalskag tagging site to upstream escapement projects are: Aniak River Sonar (74), George River weir (204), Tatlawiksuk River weir (319), Kogrukluk River weir (461), and Takotna River weir (586).

An effort was undertaken prior to the 2004 field season to calculate distances along the Kuskokwim River using a computer program available from Garmin Topo MapSource[1] (Table 1). The results allowed us to provide more accurate distances than in prior years and are used in this report. Weir and sonar sites have not changed but rather the distance measurements. These measurements will be used by all ADF&G project leaders in annual reports beginning in 2004 (Costello et al. 2005; McEwen 2005; Stewart and Molyneaux 2005; Stewart et al. 2005; Whitmore et al. 2005).

The Lower Kalskag/Aniak fish wheel sites were selected because: (1) they were located far enough inland (approximately 250 rkm) where anadromous fish should be physiologically adjusted to the freshwater environment; therefore, more tolerant of capture and tagging stresses, (2) harvest of tagged fish would be reduced, because they were located above Bethel (106 rkm), where approximately one-third of the drainage-wide harvest occurs, (3) the sites are below many salmon spawning streams, (4) the water velocity was assumed to be adequate for fish wheel operation and (5) the distance between the two sites was assumed to be far enough that the tagged fish would mix with untagged fish.

A new site was selected for the fish wheels operated in the Kuskokwim River near Lower Kalskag, in contrast to the Kalskag location used in the previous 3 years studies. The site was moved downstream to improve project design. It was believed that the move downstream would increase catch rates of target species by having the wheels operate in a single channel rather than a channel bypassed by other channels. It was also believed that the move would help decrease the bias associated with being in close proximity to the Aniak River confluence.

PROJECT DATES

Fish wheels and drift gillnets were used for capturing salmon from June 7 to September 8 at the Lower Kalskag site and from July 18 to September 10 at the Aniak site. Tag recovery at upstream escapement projects occurred from June 25 to July 31 at the Aniak River sonar site, June 27 to September 24 at the George River weir, June 15 to September 18 at the Tatlawiksuk River weir, June 21 to September 25 at the Kogrukluk River weir, and from June 23 to September 18 at the Takotna River weir.

The start and end dates of field operations were selected to ensure sampling occurred throughout the migration of sockeye, chum, and coho salmon past the Lower Kalskag fish wheel site and coho salmon only past the Aniak site. The start date at the Lower Kalskag site needed to be prior to significant passage of chum and sockeye salmon whose run timing precedes that of coho salmon. The Aniak fish wheel site started later than in past study years due to budget constraints and the abundance estimate recapture event focusing solely on coho salmon.

In 2002, the investigators began fishing June 18 at the Kalskag site, and expected low catches based on historic Bethel Test Fish data (Ward et al. 2003) and on local TEK. However, when fishing began, chum salmon had already been passing the tagging site and their numbers were building. In 2003, the project started 12 days earlier (June 6) and the first sockeye salmon was not captured until June 13, and chum salmon catches were one per day. Based on the 2003 catch rates, we started fishing on June 7 at Lower Kalskag.

[1] Product names used in this report are included for scientific completeness but do not constitute a product endorsement.

The Aniak fish wheels were started on July 18 to recapture coho salmon for the abundance estimate. This date was chosen to include the beginning of the run based on previous year's data from this study. In both 2002 and 2003, less than 1% of the total coho salmon catch at the Aniak fish wheel site was captured by July 18.

The end dates for field operation were selected to sample coho salmon near the end of the run, while allowing ample time for coho salmon to reach upstream escapement projects. Researchers are aware that estimating the entire coho salmon return was unrealistic because coho salmon continue their migration into the fall, perhaps even after the river has frozen, which is a typical characteristic for coho salmon (Carlon 2000; Jones III and McPherson 1997; Jones III et al. 2001; Ericksen 1999). However, estimating coho salmon stocks vulnerable to harvest was considered an achievable goal. To this end, project end dates were selected (September 8 at Lower Kalskag and September 10 at Aniak) to encompass coho salmon stocks vulnerable to harvest by considering ending dates at upriver escapement projects, travel speed, and harvest pressures. Upriver weir operations generally cease by September 20 because it is thought most of the coho salmon escapement has been counted by that time. In years when weirs have operated beyond September 20, the counts of coho salmon have accounted for only 0.1% to 2.1% of the return (Ward et. al. 2003). To allow enough time for tagged coho salmon to reach upriver escapement projects, we used travel time information results from 2001–2003 (Kerkvliet and Hamazaki 2003; Kerkvliet et al. 2003; Kerkvliet et al. 2004). Subsistence, commercial, and sport fishing activities decline in September when most subsistence needs are met, commercial openings are rare, and sport fishing activities are reduced. Therefore, we define our "target operational period" as those coho salmon passing the tagging site through September 8.

CAPTURE METHODS

Fish Wheels

Four fish wheels were used to capture salmon. One pair (right and left bank) was anchored downstream from Lower Kalskag (249 rkm) and the second pair downstream from Aniak (294 rkm) (Figure 2). Right bank wheels were defined as wheels anchored on the right side of the river when facing downstream. Each fish wheel consisted of 3 aluminum capture baskets measuring 2.4 by 3.0 m (length, width), a perforated plywood live box measuring 2.4 by 1.2 by 0.6 m (length, width, depth) attached to the offshore side of each wheel, and a weir measuring 5 m (length) positioned perpendicular to the bank along the onshore side of each fish wheel.

Fish wheels were operated continuously, except for periods of maintenance, readjustment, or relocation. However, record low water levels ultimately caused the right bank fish wheel to stop working at the Lower Kalskag site the last 7 days of the season, and a broken basket sleeve caused the right bank wheel at the Aniak site to be shut down the last 3 days of the season. Two crews, consisting of 2 people, were assigned to work a 7.5-hour shift each day. During each shift, a crew sampled fish from each wheel approximately every 2 hours. However, between shifts, fish were held longer than 2 hours. Initially, two shifts ran from 0600 to 1400 hours and from 1800 to 0200 hours. As the season progressed and daylight hours shortened, the schedule was progressively adjusted until by the end of the season they ran from 0700 to 1500 hours and 1700 to 0100 hours.

Drift Gillnets

Drift gillnets were used to intercept coho salmon migrating offshore from the fish wheels for tag deployment at the Lower Kalskag site, and for tag recovery at the Aniak site. Drifting was conducted between fish wheel checks at the Lower Kalskag site from July 24 to September 8. Drifting for tag recovery was conducted from July 26 to September 10 at the Aniak site.

Drift gillnet locations were identified at the Lower Kalskag and Aniak sites. Locations were chosen based on operational success, capture success, and to characterize salmon passing offshore to the fish wheels; therefore, drifting occurred further offshore from the fish wheels. At each site, 3 drift locations were primarily used. A mesh size of 4 in (10.16 cm) was used for gillnetting. Gillnets measured 45 meshes deep and were either 5 fathoms or 10 fathoms in length. The net length was based on catch rates; 5-fathom nets were used when catch rates were high. Crews deployed the nets from an 18 or 20 ft skiff, and immediately began retrieving the net at the first sign a fish was entangled.

Fish captured by the drift gillnet crews were processed for tag deployment or for tag recovery in the following way. Species other than coho salmon were immediately released. Coho salmon were freed from the net and lifted into the skiff where they were placed into a tub of fresh river water. At the deployment site coho were then tagged, and released. When too many coho salmon were caught at the deployment site, excess fish were immediately released without tagging. At the Aniak recovery site, coho salmon captured in drift gillnets were placed into a tub and were inspected for tags and secondary marks, and then released.

TAG DEPLOYMENT

Tagging of sockeye, chum, and coho salmon consisted of one primary and one secondary mark. The primary mark was a 36-cm spaghetti tag reinforced with jeweler wire. Each tag had a unique identification number and the phone number of the ADF&G Anchorage office. Two tag colors were deployed at the Lower Kalskag site: white for salmon caught by fish wheels and fluorescent green for salmon caught by drift gill nets. Each tag was sewn through the back just below the dorsal fin and about 4 rays up from the posterior side of the dorsal fin. It was secured by crimping both ends of the spaghetti tag together in a brass sleeve.

The secondary mark required a single-hole paper punch to cut a hole in the adipose fin. Secondary marks were used to assess tag loss. Non-target species bycatch and unhealthy salmon were identified, counted, and then released without a tag or secondary mark.

Salmon selected for tagging were placed in a padded aluminum cradle suspended in a tub filled with pumped river water. Data collected on each tagged fish consisted of fish condition and fish color, which were based on a scale from 1 to 4. Fish color indicated spawning condition (i.e., bright, some color, obvious color, spawning color) and fish condition indicated fish health (i.e. good, minor wound, major wound, dead). Other auxiliary information collected at the time of sampling included taking genetic samples from 60 chum salmon daily when possible. Samples were obtained by clipping off the auxiliary process from each fish and storing in a numbered vial. Length, sex, and scales used to determine age were not collected, unlike years past.

At the Lower Kalskag site, all sockeye, chum, and coho salmon were tagged with spaghetti tags with the exception of sockeye and chum salmon caught in drift gillnets, escaped during handling, were determined unhealthy, or were spawned out. Crews at the Aniak site did not tag any fish, but rather focused effort on tag recapture. Sockeye and chum salmon were not tagged from drift

gillnets because of a change in the project design in response to a budget reduction, which eliminated estimating abundance of the two species and delayed the start of gillnetting to accommodate only the coho run.

TAG RECOVERY

An effort to recover tagged salmon was conducted at the Aniak site, all tributary escapement monitoring projects, and was encouraged of members of the public (volunteers). Tags were also occasionally recovered at the Lower Kalskag site. The objective for tag recapture at the Aniak site was for estimating coho salmon run abundance only, hence the late operational period of July 18 to September 10.

Tag recovery occurred at the Aniak site using fish wheels and gillnets. Crews recorded the date, tag number and tag color for all recaptured fish with tags. Tag loss was also assessed at the Aniak site by examining all untagged coho salmon for secondary marks. Adipose fins were removed from all untagged coho salmon captured at the Aniak site as a way of identifying possible recaptures.

Seven escapement projects within the drainage recovered tags released from the Lower Kalskag site (Figure 1). Of the escapement projects, two were located downstream of the tagging site, and five were located upstream. The downstream escapement projects were located on the Tuluksak and Kwethluk rivers (lower basin), and the upstream escapement projects were located on the Aniak, George, and Kogrukluk rivers (middle basin), and the Tatlawiksuk River and Takotna River (upper basin). The Aniak River sonar crew captured tagged fish in beach seine nets while weir crews captured tagged fish as they passed through the weir. Fish were described as "recovered" when crews were able to capture the fish and record the tag number and date recovered. They were recorded as "observed" when crews could not capture tagged fish because of high water or capture difficulties, they recorded tag color and date observed. Tag loss was identifiable by an untagged salmon with a secondary mark. Tag loss was assessed at the weir sites by inspecting untagged fish during routine age, sex, and length (ASL) sampling. Details of weir and sonar operations are documented for the Kwethluk River by Roettiger et al. (2005), for the Tuluksak River by Zabkar et al. (2005), for the Aniak River by McEwen (2005), for the George River by Stewart et al. (2005), for the Kogrukluk River by Shelden et al. (2005), for the Tatlawiksuk River by Stewart et al. (2005), and for the Takotna River by Costello et al. (2005).

Tagged fish were also caught by subsistence, commercial, and sport fishers who were encouraged to return tags through a tag lottery reward system advertised through posters, radio announcements, and public meetings. Fishers willing to participate in the lottery could provide tag information by calling an Anchorage ADF&G Regional office toll-free phone number, calling or visiting the ADF&G Bethel office, any Kuskokwim River tribal office, the Kuskokwim Native Association, or the Yukon Delta National Wildlife Refuge office. Recovery data were recorded on paper forms then entered into an Access database postseason. Tag numbers were matched to the 2004 data set, but if a tag number did not match the 2004 data set, it was checked against previous year's databases.

DATA ANALYSIS

Data Entry

Data on environmental conditions, fish tagged, fish recaptured, and shift information such as date, time, location, etc., were entered daily into a Juniper Systems Allegro CE data logger by

crews as they tagged or recaptured salmon from fish wheels and drift gillnets. After each shift, data from the data loggers were downloaded onto computers where they were converted into Excel spreadsheets at each site. Tag recovery information from weirs and from volunteer recaptures was recorded on paper at respective reporting locations.

Postseason all spreadsheet data were imported into an Access database. Recovery data collected from weirs or members of the public were entered manually. Data extracted from the database were analyzed for run timing, travel speed, and used to calculate coho salmon run abundance.

Stock-specific Run Timing

Release dates of fish tagged at the Lower Kalskag site and later recovered at upriver weir sites or recovered by volunteer members of the public were used to estimate run timing of stocks past Lower Kalskag. Visual comparisons among stocks were conducted using curves of cumulative percent by date tagged at Kalskag of fish recovered from weirs. Tributaries or areas of the drainage from which more than 4 tags were recovered by the public (volunteer recoveries) were added to this review. Voluntary recoveries were pooled within a drainage and the cumulative percent by date was calculated even though they were actually recovered throughout the drainage (i.e. confluence to headwaters). Dates of voluntary recoveries were not adjusted to represent when they all might have passed a common location. For example, voluntary recoveries from the lower reaches of the Holitna were pooled with recoveries from the headwaters to estimate the mean run timing into the Holitna River.

Volunteer tag recoveries were selectively chosen based on information provided that allowed us to place them with high confidence within certain Kuskokwim River tributaries. This analysis was an effort to utilize the many volunteer tag recoveries and to test our existing assertion that stocks traveling further upstream are tagged earlier than stocks traveling shorter distances. A source of bias associated with using volunteer tag recoveries includes inconsistent effort over time for tag recoveries at tributaries that could bias run timing estimates early or late. Also, in our analysis of tag recoveries from escapement projects, we know where tags are recovered to the mile for that tributary. However, when using volunteer tag recoveries we have mixed information as to the specific location along a certain tributary, and sometimes have recoveries from different areas of a tributary and therefore cannot really assign a distance traveled to use in the run timing comparisons.

In fully understanding this type of data, one needs to be aware of potential biases when the behavior of tagged fish is not the same as untagged fish. There is ample literature that initially after tagging, fish "sulk" (Jones III et al. 2001; Bernard et al. 1999). When sulking behavior is considered in run timing and travel speed, the travel time of tagged fish would likely be slower than untagged fish. Furthermore, run timing of tagged fish at escapement projects would lag behind that of untagged fish. Also, it is important to consider biases arising if not tagging salmon in proportion to the run. This can be caused when water levels fluctuate creating poor conditions and causing catch rates to decrease during certain periods.

Travel Speed

Travel speed (rkm/day) for each tagged salmon was calculated as the difference in rkm between the Lower Kalskag tagging site and location of tag recovery divided by the number days between time of release from the tagging site and recovery event:

Travel speed = [distance (rkm) between tagging site and recaptured location]/[recaptured date - tagged date].

Travel speeds were calculated from the Lower Kalskag tagging site to the Aniak recapture site, and from the Lower Kalskag tagging site to upriver escapement projects for the purpose of stock comparison. Travel speed does not presume salmon actually travel this speed. It assumes a point-to-point path to the recovery location and no response to handling, and downstream or meandering movements. Again, by comparing between recovery locations any point-to-point travel is assumed constant among stocks.

A linear model was used to examine factors influencing travel speed, in which travel speed was assumed to be a normal random variable and was regressed with Julian date, total travel distance, and their interaction term. The linear model was fit using the GLM procedure in SAS version 8.02 (SAS Institute Inc. 1999). A full model consisting of each explanatory variable and their interaction was initially fit to the data. Non-significant terms were eliminated from the model sequentially beginning with the interaction term. If a non-significant interaction term was eliminated, the model was refit and any non-significant main effects were removed from the model.

Abundance Estimate Diagnostics

For the estimate of coho salmon run abundance from the closed population mark–recapture experiment to be unbiased, certain assumptions need to be fulfilled (Seber 1982). The general requirements for an unbiased estimate from a two-event mark–recapture experiment on a closed population expressed relative to this project are:

1. Tagging a fish will not affect its probability of being recaptured,
2. Tagged fish did not lose their marks between sampling events; and
3. The population is closed, no immigration or emigration occurs over the course of the experiment.

We accounted for these assumptions in this project as follows:

Assumption 1

The length of time a fish is held in the live box and handling during tagging might influence fish survival or susceptibility to the recapture fish wheels. To minimize the effects of handling, coho salmon were quickly placed in a padded cradle inside a tub of river water, tagged, and released. Since the wheels were only sampled during specific intervals it is impossible to know exactly when each fish entered the live box therefore an exact holding time can not be calculated. An estimate of the holding time for an individual fish was calculated as the difference between the time the fish was sampled and the midpoint between when the tagging fish wheel began fishing and the starting of the sampling shift. The probability of a tagged fish being recaptured was modeled as a function of holding time using the logistic procedure in SAS version 8.02 (SAS Institute Inc. 1999).

Assumption 2

All fish caught at the Lower Kalskag and Aniak sites were examined by visual inspection for secondary marks to evaluate tag loss. This same procedure was incorporated into the age, sex, and length (ASL) protocol at upriver escapement projects where ASL sampled salmon were examined for secondary marks.

Assumption 3

To meet the third assumption and ensure that our coho salmon target population had a non-zero probability of being tagged at the Lower Kalskag site and recaptured at the Aniak site or upriver escapement projects, tagging was conducted between June 7 and September 8 and recovery at the Aniak site from July 18 to September 10. The start date for tag deployment was chosen based on the earlier run timing of sockeye and chum salmon resulting in few or no coho salmon would be caught initially and the ending date was chosen so that coho catches would have waned to zero or to a few fish daily. This is consistent with a salmon life history centered about a seasonal migration.

Abundance Estimate

Data used to estimate coho salmon run abundance in 2004 were from the first mark–recapture opportunity provided by this project. These data are from the marking (spaghetti tags) of coho salmon at the Lower Kalskag site (249 rkm) and sampling for tag recovery at the Aniak site (294 rkm) on the Kuskokwim River (Figure 1; Table 1). To account for temporal variation in capture probabilities and partial mixing of tagged coho salmon, sampling was stratified. Sampling was divided into 9 weekly strata beginning Sunday, July 11 and continuing through Saturday, September 11, 2005. To evaluate if tagging effort was proportional to the run size. A chi-square test of homogeneity was used to test this assumption of equal tagging probability. Weekly strata with the similar tagging probability were combined. The weekly proportion recaptured (proportion of tagged fish released at the tagging wheels that were subsequently recaptured in the recovery wheels) was used to test the assumption of constant probability of recapture in the recover wheels. A chi-square test of homogeneity was used to test the assumption of equal recapture probability and weekly strata with equal recapture probabilities were combined. An abundance estimate, standard error (SE), and 95% CI were calculated using the Maximum Likelihood estimate of the Darroch Estimator (Seber 1982) from SPAS (Arnason et al. 1996).

$$\hat{U} = u' M^{-1} a \,, \tag{1}$$

$$u = \begin{bmatrix} u_1 \\ \vdots \\ u_j \\ \vdots \\ u_t \end{bmatrix} \qquad a = \begin{bmatrix} a_1 \\ \vdots \\ a_i \\ \vdots \\ a_s \end{bmatrix} \qquad M = \begin{bmatrix} m_{11} & \cdots & m_{1j} & \cdots & m_{1t} \\ \vdots & \ddots & & \iddots & \vdots \\ m_{i1} & & m_{ij} & & m_{it} \\ \vdots & \iddots & & \ddots & \vdots \\ m_{s1} & \cdots & m_{sj} & \cdots & m_{st} \end{bmatrix} \tag{2}$$

where:

$\hat{U}$ = the estimated abundance of untagged fish in the population at the Lower Kalskag site,

u_j = the number of untagged fish in the *j*-th stratum at the Aniak site,

a_i = the number of tagged fish released in the *i*-th stratum at the Lower Kalskag site; and;

m_{ij} = the number of tagged fish released in *i*-th stratum at the Lower Kalskag site and recaptured in the *j*-th stratum at the Aniak site.

RESULTS

TAG DEPLOYMENT

Tag deployment was only conducted from the Lower Kalskag site in 2004. The fish wheels at the Lower Kalskag site had lower revolutions per minute (rpm) compared to the Aniak site, and it is believed that the rpm were higher at last year's fish wheel site right above Kalskag. The lower rpm were probably due to there being less of a gradient and the current being considerably slower at the Lower Kalskag site. There were also fewer ideal locations within the proximity of camp to deploy the fish wheels that would allow them to fish near the bottom of the river, resulting in more effective catching of salmon. Thus, when water levels fluctuated causing a current site to become unusable, the fish wheels were then moved to less productive sites. Tag deployment using drift gillnets was entirely focused on coho salmon, as this was the only species for which abundance was being estimated.

Sockeye Salmon

Fishing for sockeye salmon with fish wheels began June 7 and ended September 8 at the Lower Kalskag site, but the first sockeye salmon was not captured until June 9 (Appendix A1). Fishing did not begin at the Aniak site until July 18 and ended September 10 (Appendix A2). The peak catch per hour occurred from June 25 to June 29 at Lower Kalskag (Figures 3 and 4). Daily catches dropped to less than 10 sockeye salmon per day at Lower Kalskag in mid-August. Tag deployment is assumed to have occurred throughout the sockeye salmon run past the tagging site.

A total of 1,885 sockeye salmon were tagged at the Lower Kalskag site between June 9 and September 5, using fish wheels (Table 2; Appendix A1). More sockeye salmon were caught in the right bank fish wheel (62%, n=1,257), whereas at the Aniak site more sockeye were caught in the left bank fish wheel (85%, n=886). Very few sockeye salmon were caught using gillnets because the majority of the run had passed by the time drift gillnetting began in late July, and because sockeye salmon tend to run closer to the banks, whereas the gillnetting effort took place offshore from the fish wheels.

Crews tagged 96% (1,885/1,956) of the sockeye salmon captured in fish wheels at the Lower Kalskag site (Table 2; Figure 5). The sockeye salmon released untagged were either unhealthy (injured, spawned out, nearly spawned out), or escaped during handling.

Chum Salmon

Chum salmon were present the first day of operation at the fish wheels on June 7, but daily catches remained under 10 chum salmon per day through June 20 at the Lower Kalskag site (Appendix B1). Catch totals were already very high when the Aniak site started on July 18 (Appendix B2). Chum salmon were captured through September 8 at the Lower Kalskag site and September 10 at the Aniak site. The highest daily catch per hour at the Lower Kalskag site occurred from July 16–18 (Figures 6 and 7). Daily catches were less than 20 chum salmon per day at the Lower Kalskag site after August 31 representing less than 2% of the season total. Tag deployment is assumed to have occurred throughout the chum salmon run past the tagging site.

A total of 5,276 chum salmon were tagged between June 7 and September 8 using fish wheels (Table 3; Appendix B1). More chum salmon were caught in the left bank fish wheels at the Lower Kalskag (61%, n=3,550) and Aniak sites (79%, n=14,150) (Table 3; Appendix B1 and

B2). Very few chum salmon were caught using gillnets because the majority of the run had passed by the time drift gillnetting began in late July.

Crews tagged 94% (5,276/5,608) of the chum salmon captured in fish wheels at the Lower Kalskag site (Table 3; Figure 8). The chum salmon released untagged were either unhealthy (injured, spawned out, nearly spawned out), or escaped during handling.

Coho Salmon

The beginning of the coho migration was sampled as the first coho salmon was caught July 11 at Lower Kalskag and catches did not exceed 10 per day until July 26 (Appendix C1). At the Aniak site, the first 26 coho salmon were caught July 18, which was the first day of operation (Appendix C2). In contrast, catches were still strong during September when the project ended, averaging over 40 coho salmon per day at the Lower Kalskag site and close to 80 coho salmon per day at the Aniak site. Catches at the Lower Kalskag site began to increase the last 5 days with only one wheel operational. Peak fish wheel catch per hour at the Lower Kalskag site occurred from August 11 to August 14 with catches exceeding 120 per day (Figures 9 and 10). At the Lower Kalskag site, the peak gillnet CPUE occurred from August 11 to August 17 (Figure 11). At the Aniak site, peak fish wheel CPUE's occurred from August 12 to August 19 with catches averaging 377 per day. It is unlikely the period of tag deployment fully encompassed the coho salmon run in 2004.

A total of 2,971 coho salmon were tagged between July 11 and September 8 using a combination of fish wheels and drift gillnets at the Lower Kalskag site (Table 4; Appendix C1). Most coho salmon were captured with the right bank fish wheel at the Lower Kalskag site (47%, n=1,440), as well as at the Aniak site (54%, n=5,673). Drift gillnets accounted for 21% (n=662) of the coho salmon captured at the Lower Kalskag site and 7% (n=740) of coho salmon captured at the Aniak site.

Crews tagged 98% (2,971/(3,089-47)) of coho salmon caught with fish wheels and gillnets at the Lower Kalskag site (Table 4; Figure 12). The coho salmon released untagged were either unhealthy (injured, spawned out or nearly spawned out) or escaped during handling.

TAG RECOVERY

Efforts to recover tagged salmon occurred throughout the Kuskokwim River drainage to include staff at mainstem and tributary escapement monitoring projects and volunteer fishers. Tags were recovered at the Aniak tag recovery site on the Kuskokwim River, recovered or observed at weirs or a sonar site on tributaries, and information and tags returned from subsistence, commercial, and sport fishers.

Sockeye Salmon

Fish wheels and gillnets caught a total of 1,052 sockeye salmon at the Aniak tag recovery site and 108 were tagged (Table 2; Appendix A2). Most of these tagged salmon were originally caught in the right bank fish wheel at Lower Kalskag and then crossed the river to be recaptured in the left bank fish wheel at Aniak (n=62) (Figure 13). Of the tagged sockeye salmon, 39% (n=42) were captured and recaptured along the same bank, 3% (n=3) crossed from left to right bank, and 1% (n=1) was captured and recaptured using a combination of gillnets and fish wheels (Figure 13). The majority of sockeye salmon recaptured at the Aniak site were recaptured in the left bank fish wheel (92%; n=99).

A total of 60 tagged sockeye salmon were recovered or observed at escapement projects (Table 5; Appendices D1–D5). Of the 1,885 tagged sockeye salmon, 0.4% (n=8) were recovered or observed from escapement projects downstream of the tagging sites, and 2.8% (n=52) were recovered or observed from escapement projects upstream of the tagging site, with the Kogrukluk River weir accounting for 33 of the recaptured or observed fish, and the George River weir accounting for 14 (Appendices D2 and D4).

Stock-specific bank orientation of migrating sockeye salmon at the tagging site was evident when comparing the percent by location and gear of (1) recoveries at upstream escapement projects with (2) all tags deployed at Lower Kalskag (Table 6; Figure 14). The percentage of sockeye salmon recovered at the Kogrukluk River weir site that were tagged from the right bank (77%; n=24) was higher than the general tagging effort at Lower Kalskag (62%; n=1,175). This difference was even greater for George River sockeye salmon (85% versus 62%). Conversely, the few recoveries at the other tributary projects were all tagged from the left bank.

There were 92 tags returned from subsistence, commercial and sport fisheries (Table 7; Appendix E1). Of the 1,885 tags deployed, 2.5% (n=48) were recovered by volunteers downstream of the tagging site and 2.3% (n=44) recovered by volunteers upstream of the tagging site. Most of the 44 tags returned above the tagging sites were recovered on or near the Stony River (n=13) and from the Holitna River drainage (n=9). Of those recovered downstream, one was from the subsistence fishery outside the Kuskokwim River near Quinhagak. Of the 13 recovered on or near the Stony River, 8 were tagged on the right bank fish wheel (52%), and of the 6 recovered on the Aniak River, 5 were tagged from the left bank (83%).

Chum Salmon

A total of 18,083 chum salmon were caught at the Aniak site of which 632 were tagged (Table 3; Appendix B2). A total of 77% (n=487) were captured and recaptured on the same bank, 23% (n=143) were captured and recaptured on the opposite bank, and <1% (n=2) were tagged and recaptured using a combination of fish wheel and gillnet (Figure 15). The majority of chum salmon recaptured at the Aniak site were caught in the left bank fish wheel (88%, n=560) (Figure 15).

A total of 97 tagged chum salmon were recovered or observed at escapement projects (Table 8; Appendices D1–D5). Of the 5,276 chum tagged at the tagging sites 0.04% (n=19) were recovered/observed from escapement projects downstream from the tagging sites and 1.5% (n=78) were recovered or observed from escapement projects upstream of the tagging site, with the George River weir accounting for 62, and the Tatlawiksuk River weir accounting for 8 (Appendices D2 and D3).

Stock-specific bank orientation of migrating chum salmon at the tagging site was evident when comparing the percent by location and gear of (1) recoveries at upstream escapement projects with (2) all tags deployed (Table 9; Figure 16). The percentages of chum salmon recovered at upstream weirs that were tagged from the right bank fish wheel were substantially higher (62% to 100%) than the percentage of all tags released (38%, n=1,985). In contrast, the few tags that were recovered during beach seining activities by the Aniak River sonar crew were all tagged from the left bank fish wheel (n=5). No tagged chum salmon were recovered at the Takotna River weir.

There were 141 tags returned from subsistence, commercial and sport fisheries (Table 10; Appendix F1). Of the 5,276 chum salmon tagged, 0.8% (n=41) were recovered by volunteers downstream of the tagging site and 1.9% (n=100) were recovered by volunteers upstream of the tagging site. Approximately 63% (n=63) of the tags recovered near or above the tagging site were collected near the Aniak River. Of the tags recovered in the Aniak River 78% were tagged from the left bank fish wheel.

Coho Salmon

A total of 10,544 coho salmon were caught in fish wheels or gillnets at the Aniak tag recovery site of which 81 were tagged (Table 4; Appendix C2). Most tagged coho salmon were originally captured and then recaptured on the same bank (61%; n=49); 33% (n=27) were captured and recaptured on the opposite bank, 5% (n=4) were captured and recaptured using a combination of gillnets and fish wheels, 1% (n=1) were captured and recaptured in gillnets (Figure 17). The majority of coho salmon recaptured at the Aniak site were caught in the right bank fish wheel (54%; n=44; Table 4).

A total of 118 tagged coho salmon were recovered or observed at escapement projects (Table 11). Of the 2,969 coho salmon tagged at the tagging sites 0.1% (n=3) were recovered/observed at escapement projects downstream of the tagging site and 3.9% (n=115) were recovered/observed upstream of the tagging sites, with Tatlawiksuk River weir accounting for 35 fish and the Kogrukluk River weir accounting for 54.

Stock-specific bank orientation of coho salmon at the tagging site was evident when comparing the percent by location and gear of (1) recoveries at upstream escapement projects with (2) all tags deployed (Table 12; Figure 18). Again, a higher percentage of recoveries at weirs were tagged from the right bank fish wheel (52% to 100%) than total deployment (46%; n=1,380). At the George River weir, 60% (n=3) of the recovered tags were tagged from the right bank fish wheel while only 46% of total tags were released from this location. At the Tatlawiksuk River weir, 73% (n=24) of the recovered tags were tagged from the right bank fish wheel while 15% (n=5) were tagged using gillnets and 12% (n=4) were tagged from the left bank fish wheel. At the Kogrukluk River weir, 52% (n=16) of the recovered tags were tagged from the right bank fish wheel, 32% (n=10) were tagged from drift gillnets, and 16% (n=5) were tagged from the left bank fish wheel. In contrast, 100% (n=5) of tags recovered at the Takotna River weir were tagged from the right bank fish wheel. Downstream recoveries were tagged from the left bank fish wheel and from a drift gillnet (Table 12).

There were 105 tags returned from subsistence, commercial and sport fisheries (Table 13; Appendix G1). Of the 2,969 coho salmon tagged at the tagging site, 1.2% (n=37) were recovered downstream of the tagging site, and 2.3% (n=68) were recovered near or upstream of the tagging site. Of the tags recovered upstream or near the tag site, approximately 59% (n=40) were recovered near or in the Aniak River. Of the 20 tags recovered in the Aniak River, 55% (n=11) were tagged from the left bank fish wheel, 20% (n=4) from the right bank, and 25% (n=5) from drift gillnets.

STOCK-SPECIFIC RUN TIMING

Sockeye Salmon

Run timing was estimated for all sockeye salmon captured at the Lower Kalskag site pooled, and for sockeye salmon bound for George and Kogrukluk rivers as the only weirs sites with

sufficient tag recoveries. Sockeye salmon bound for the Kogrukluk weir passed Lower Kalskag earlier than the pooled run timing, while George River sockeye salmon exhibited later run timing (Figure 19). The median capture date of sockeye salmon at the Lower Kalskag tagging site was July 14 (n=2,027; Appendix A1). The central 80% of the total catch (10% cumulative to 90% cumulative) were captured from June 25 through August 8. The median capture date at Lower Kalskag of sockeye salmon subsequently recaptured at the Kogrukluk River weir was June 29, while the median capture date of sockeye salmon subsequently recaptured at the George River weir was August 1 (Table 14).

Differences varied among stocks for run timing of escapement of tagged and untagged sockeye salmon counted past the weirs (Table 14). By August 12, 50% of the escapement (untagged fish) was counted at the George River weir (177/2), while 50% of the recaptured tagged sockeye salmon were counted by August 9 (n=13), a 3 day difference. By July 12, 50% of the escapement was counted for the Kogrukluk River weir (6,767/2), while 50% of the recaptured sockeye salmon were counted by July 26 (n=31), 14 days later.

Volunteer recoveries of sockeye salmon were pooled for the Stony River (n=6) and for the Aniak River (n=5) to estimate run timing into those systems and to compare it with weir recovery sites. Stony River sockeye recoveries were the earliest tagged followed by those recovered at the Kogrukluk River weir, Aniak River, and George River weir (Figure 20). In 2004, the upriver stocks (Stony and Kogrukluk) are separated in time from the stocks closer to the tagging site (George and Aniak).

Chum Salmon

Run timing was estimated for all chum salmon captured at the Lower Kalskag site pooled, and for chum salmon bound for Aniak, George, Tatlawiksuk and Kogrukluk rivers separately. Kogrukluk River and Tatlawiksuk River chum salmon stocks passed the Lower Kalskag site earlier (Figure 21) than all chum salmon pooled. George River and Aniak River chum salmon more closely followed the pooled run timing. The median capture date of chum salmon at the Lower Kalskag tagging site was July 22 (n=5,896; Appendix B1). The central 80% of the total catch (10% cumulative to 90% cumulative) were captured from July 7 through August 13. The median capture dates of chum salmon subsequently recaptured at escapement projects on the Aniak, George, Tatlawiksuk and Kogrukluk rivers ranged from July 22 (Aniak; n=5) to June 30 (Kogrukluk; n=2) (Table 15).

Differences varied among run timing of tagged and untagged chum salmon counted past weir and sonar sites (Table 15). By July 15, 50% of the escapement (untagged) was counted at the Aniak River sonar, July 11 at the George River weir (13,058/2), and July 14 at the Tatlawiksuk River (24,174/2) and Kogrukluk River weirs (22,514/2) (Table 15). Median recapture dates of tagged chum salmon was July 28 at the Aniak River sonar, July 24 at the George River weir, July 10 at the Tatlawiksuk River weir, and July 16 at the Kogrukluk River weir. Differences between median date of untagged and tagged chum salmon ranged from 4 days earlier at the Tatlawiksuk River weir, 2 days later at the Kogrukluk River weir, to 13 days later at the Aniak River sonar site and George River weir.

Voluntary recoveries of tagged chum salmon were pooled for the Aniak River (n=63) and used to estimate run timing past the tagging site (Figure 22). The run timing of voluntary tags was much later than those from the sonar site and was also later than other upriver stocks. The sonar

project ended July 31, while over 50% of the voluntary tag recoveries were from chum salmon tagged after that date.

Coho Salmon

Run timing was estimated for all coho salmon captured at the Lower Kalskag site pooled, and for George, Tatlawiksuk, Kogrukluk, and Takotna rivers separately. Coho salmon bound for the Takotna River passed Lower Kalskag earliest followed by Tatlawiksuk River, Kogrukluk River, and George River coho salmon (Figure 23). The central 80% of the total catch at Lower Kalskag (10% cumulative to 90% cumulative) was captured from August 3 through September 1. The median capture date of coho salmon tagged at the Lower Kalskag site that were later recaptured (n=81) at the Aniak site was August 16. The median capture dates of coho salmon subsequently recaptured at weir projects on the George, Tatlawiksuk, Kogrukluk and Takotna river's were August 21 (n=5), August 12 (n=33), August 16 (n=31), and August 2 (n=5) respectively (Table 16).

The difference varied in run timing of tagged and untagged coho salmon counted past weirs or the Aniak fish wheel site (Table 16). By August 14, 50% of the coho salmon were captured at the Aniak site (n=10,544; Appendix C2). By August 31, 50% of the escapement was counted (13,248/2) at the George River weir, August 19 (26,078/2) at the Tatlawiksuk River weir, August 31 (16,410/2) at the Kogrukluk River weir and August 26 (3,207/2) at the Takotna River weir (Table 16). The median recapture date of tagged coho salmon at the Aniak site originating from the Lower Kalskag site was August 22. The median recapture dates of tagged coho salmon at the weirs were September 3 at the George River weir, August 31 at the Tatlawiksuk River weir, September 8 at the Kogrukluk River weir, and August 21 at the Takotna River weir. Differences between median date of untagged and tagged chum salmon ranged from 5 days earlier at the Takotna River weir, 8 days later at the Kogrukluk River weir, to 13 days later at the George and Tatlawiksuk River weirs.

Voluntary tag recoveries of coho salmon were pooled from the Aniak River (n=8) to estimate run timing past the Kalskag tagging site for comparison with other monitored stocks (Figure 24). In 2004, run timing differences were not great among stocks except for the early migration of Takotna River coho salmon. Aniak River recoveries were also representative of the early portion passing Lower Kalskag.

STOCK-SPECIFIC TRAVEL SPEED AND TRAVEL DAYS

Sockeye Salmon

Due to small sample sizes, analysis of travel speed as a function of Julian date and travel distance was only modeled for the George River weir and the Kogrukluk River weir. Travel speed of tagged sockeye salmon differed significantly by Julian date (F-value=13.96; df=1; P=0.0006), but not by distance traveled (F-value=0.69; df=1; P=0.4118). The mean travel speed and days traveled for sockeye salmon tagged at the Lower Kalskag site and recaptured at the Aniak site was 21 rkm/day (n=107; SD=12.0) (Table 17; Figure 25). The number of days between tagging at the Lower Kalskag site and recapture at the Aniak site averaged 3 days and ranged from 1 to 22 days (n=108) (Table 17). There were 18 fish recaptured at the Aniak site one day after they were tagged at the Lower Kalskag site. One sockeye salmon was recaptured 22 days after being tagged at the Lower Kalskag site.

Tag recoveries from upstream escapement projects did not show an increase in travel speed with an increase in distance from the tag site, but instead showed an inconsistent mixture of travel speeds (Table 17). The mean travel speed of fish recovered at the Aniak River sonar was 11 rkm/day (n=1), George River weir was 27 rkm per day (n=13; SD=6.4), at the Tatlawiksuk River weir 27 rkm per day (n=2; SD=7.5), at the Kogrukluk River weir 22 rkm per day (n=31; SD=5.9), and at the Takotna River weir was 23 rkm per day (n=1).

Chum Salmon

Travel speed was modeled as a function of Julian date and travel distance for the Aniak River sonar, George River weir, Tatlawiksuk River weir, and Kogrukluk River weir. Travel speed of tagged chum salmon differed significantly by Julian date (F-value=6.61; df=1; P=0.0123), travel distance (F-value=6.25; df=1; P=0.0148) and the interaction of Julian date and travel distance (F-value=6.32; df=1; P=0.0143). In general, tag recoveries from upstream escapement projects showed an increase in travel speed with an increase in distance from the tag site (Table 18; Figure 25). The mean travel speed and days traveled for chum salmon tagged at the Lower Kalskag site and recaptured at the Aniak site was 24 rkm per day (n=630; SD=10.6) (Table 18; Figure 26). The number of days between tagging at the Lower Kalskag site and recapture at the Aniak site averaged 2 days and ranged from 1 to 35 days (n=630) (Table 18). There were 116 fish recaptured at the Aniak site 1 day after they were tagged at Lower Kalskag. One chum salmon was recaptured 35 days after being tagged in Lower Kalskag. Mean travel speed of fish recovered at the Aniak River was 17 rkm per day (n=5; SD=7.2), at the George River weir 29 rkm per day (n=58; SD=5.7), Tatlawiksuk River weir 35 rkm per day (n=7; SD=4.1) and the Kogrukluk River weir 31 rkm per day (n=2; SD=10.9).

Coho Salmon

Travel speed was modeled as a function of Julian date and travel distance for the George River weir, Tatlawiksuk River weir, Kogrukluk River weir and the Takotna River weir. Travel speed of tagged coho salmon differed significantly by Julian date (F-value=8.68; df=1; $P \leq 0.0001$), and travel distance (F-value=22.04; df=1; $P \leq 0.0001$). The mean travel speed for coho salmon tagged at the Lower Kalskag site and recaptured at the Aniak site was 14 rkm per day (n=81; SD=8.7) (Table 19; Figure 27). The number of days between tagging at the Lower Kalskag site and recapture at the Aniak site averaged 5 days and ranged from 1 to 25 days (n=81) (Table 19). There were 3 fish recaptured at the Aniak site 1 day after they were tagged at the Lower Kalskag site. One fish was recaptured at the Aniak site 25 days after being tagged at the Lower Kalskag site. Travel speed increased as both distance from the tag site increased and as the season progressed. The coho salmon entering the river later in the season traveled at a faster rate than those entering the river earlier. The mean travel speed of fish recovered at the George River weir was 21 rkm per day (n=5; SD=8.1), the Tatlawiksuk River weir, 18 rkm per day (n=33; SD=4.6), the Kogrukluk River weir, 23 rkm per day (n=31; SD=5.4), and the Takotna River weir, 26 rkm per day (n=5; SD=2.8).

ABUNDANCE ESTIMATE DIAGNOSTICS

Analyses were conducted to assess fulfillment of assumptions necessary for an unbiased estimate of coho total run abundance. For Assumption 1, the holding effect represented by the approximate time a fish was held in the live box before it was sampled did not affect the recapture probability for coho salmon (Chi-square=0.5560; df=1; P=0.2242). In 2004, no tag loss was observed in the 1,231 coho salmon inspected for secondary marks at the George River weir

(n=220), Kogrukluk River weir (n=210), Tatlawiksuk River weir (n=353), and Takotna River weir (n=448). Furthermore, no tag loss was observed in the 1,231 coho salmon inspected for secondary marks at escapement projects in 2004 (Table 20).

COHO SALMON ABUNDANCE ESTIMATE

An estimate of coho salmon abundance upstream from the Lower Kalskag site was calculated using the Lower Kalskag and Aniak fish wheel-gillnet data set. Marking ratios at Lower Kalskag were consistent through time (Chi-square=3.01; df=8; P=0.9281). The 9 marking strata were pooled for the Darroch estimate. The recapture ratio varied through time (Chi-square=33.80; df=7; $P \leq 0.0001$) so several pooling iterations were completed to determine which strata could be pooled. The final recapture stratification consisted of 2 strata (Table 21). Weeks 2 through 6 (July 18 through August 21) were pooled for the first strata and weeks 7 through 9 (August 22 through September 11) were pooled for a second strata (Table 21; Figure 28). An estimate of the total coho salmon abundance upstream of the Lower Kalskag site using the Darroch estimator was 386,743 (95% CI=303,995; 469,492) (Table 22).

DISCUSSION

TAG DEPLOYMENT AND RECOVERY

The design and operation of this project differed from previous years. A new site at Lower Kalskag was chosen to operate fish wheels from which to deploy tags. The Aniak site was operated for tag recovery only. The operation dates of the Aniak site were chosen with the intent of estimating only the population of coho salmon and did not span the migration of sockeye or chum salmon. The new site did not perform as well as expected and fewer tags were deployed and recovered than in previous years.

The Lower Kalskag tagging site was located where the Kuskokwim River formed a single channel and we anticipated that if returns were equivalent to previous years, our catches would increase. Instead, unforeseen water events and bottom contours at the site adversely affected catch rates. First, the water rose suddenly on June 28 (Figure 29) which caused us to move the left bank fish wheel to a location along a cut bank. Catch rates at this location dropped dramatically for both sockeye and chum salmon until July 5 when it was moved back. This occurred just as sockeye CPUE's were reaching their peak. During the last month of operation, water levels dropped to record lows on the Kuskokwim River causing fish wheels to slow to barely 1 revolution per minute. The right bank fish wheel had to be shut down 6 days prior to the end of the operational period due to slow current and shallow water levels (Figure 29).

The relationship of catches at the Kalskag site and other tributary monitoring projects varied among salmon species. Though the total catch of sockeye salmon at the Lower Kalskag site is the largest in the 3 years this project has operated, and approximately 1.4 times more than the total captured in 2003, this increase is not mirrored at tributary escapement projects (Table 23). However, little is known about the distribution and abundance of sockeye salmon in the Kuskokwim River drainage. Fewer chum salmon were captured at Kalskag but drainage wide escapements were similar or higher than 2003 (Table 24). Lastly, the catch of coho salmon at Kalskag was similar to 2002 and half that of 2003. Drainage-wide escapements also indicate that coho salmon numbers were lower in 2004 than 2003 for all monitored tributaries and similar to 2002 in only a few tributaries (Table 25).

Fewer tagged salmon were recovered at weir and sonar projects in 2004 than any other year of operation but the resulting stock specific bank orientation was similar to 2003. Only two upstream escapement projects recovered more than 3 tagged sockeye salmon; George River recovered 14 chum sockeye salmon and Kogrukluk River recovered 33 sockeye salmon (Table 5). Only one upstream escapement project recovered more than 8 tagged chum salmon; George River recovered 62 chum salmon (Table 8). Missing were tagged chum salmon bound for the Kogrukluk where in 2002, 20 tags and in 2003, 47 tagged chum salmon were observed or recovered at the weir. Three weir projects recovered over 20 tagged coho salmon (Table 11). Again in 2004, salmon tagged from the right bank were more likely to be bound for drainage tributaries above the Aniak River. In contrast, voluntary and sonar site recoveries from the Aniak River were mostly from the left bank for sockeye (86%; n=7), chum (79%; n=68), and coho salmon (55%; n=20), again suggesting strong bank orientation.

Though the operation of fish wheels and gillnets at the Aniak site was delayed in 2004 for the purposes of targeting efforts on recovering tagged coho salmon, 108 tagged sockeye salmon and 632 chum salmon were recovered. These sockeye and chum salmon are from the later portions of the Kuskokwim spawning migration as recovery began at Aniak July 18 and the first sockeye and chum salmon were tagged at Lower Kalskag June 9 and June 7. Interestingly, 92% of the sockeye salmon recoveries and 89% of the chum salmon recoveries were in the left bank fish wheel at Aniak. We surmise these are mostly Aniak River salmon a tributary whose confluence is on the left bank 13 rkm upstream of the recovery site. There is a substantial run of sockeye salmon into the Aniak River based on results of a pilot radiotelemetry project in 2004 (S. Gilk, Commercial Fisheries Biologist, ADF&G, Anchorage; personal communication). Past year's results also indicate that earlier migrating sockeye salmon are more likely bound for more upriver tributaries. Lastly, in 2003 when salmon caught at Aniak were tagged, no recoveries of Kogrukluk sockeye salmon originated from the left bank fish wheels at Aniak (Kerkvliet et al. 2003). Similar run timing results would indicate that the tagged chum salmon were also bound for the Aniak River (Kerkvliet et. al. 2003, 2004).

RUN TIMING

Several assumptions are implicit in the use of recovered tags to describe migratory timing at the Lower Kalskag tagging site; furthermore, the usefulness of that knowledge to fishery managers downriver. The assumptions are that tagged fish are representative of untagged fish, i.e. that tagging occurred proportionally throughout the run and that recovery effort is also consistent. If a chronology of timing exists at Kalskag, we assume (Killick 1955) it is maintained during the earlier inriver migration for it to be of use to fishery management down river. For voluntary recoveries, there is the additional assumption that location and date of recovery are reported accurately.

Differences between the dates of median salmon passage at a weir project (untagged fish) and median date of tagged salmon at a weir project may be due to sulking or biased tag deployment. In 2003, median dates of tagged fish were later than the median date for total passage at weirs and differed by 3 days for sockeye and 1 or less days for chum salmon and 3 days for Kogrukluk and Takotna River coho salmon. This delay was not great and was attributed to sulking which does not affect run timing estimates at Kalskag. Tagged fish were judged representative of untagged fish for estimating stock-specific run timing at Kalskag. In contrast, in 2004, median dates for tagged fish at weirs were both earlier and later than total passage median dates and the differences ranged from 2 to 14 days for sockeye, chum, and coho salmon. The larger

discrepancies in 2004 are most likely due to problems with tagging stocks in proportion to abundance throughout their migration. This would have been caused by water events affecting the performance of fish wheels and resulting in low catches for tagging and low numbers of recoveries.

Because fewer salmon were tagged and recovered in 2004, these data are not powerful in describing run timing and travel speed. Furthermore, the stocks displaying large differences in mean dates between tagged and untagged salmon may also not be representative. We have placed 2004 data alongside data collected in earlier years to see if patterns are strong enough to be identified across years.

A pattern of stock-specific run timing for sockeye salmon at Lower Kalskag seems consistent for the years 2002–2004 (Figure 20). Stony River recoveries pass Lower Kalskag earlier than Kogrukluk, followed by Aniak and George River recoveries. This pattern has been described earlier noting tagged fish traveled further upstream than fish tagged later in the season (Kerkvliet et al. 2003, 2004). The separation between run timing curves of the more distant bound sockeye salmon (Stony and Kogrukluk) and stocks closer to Lower Kalskag (Aniak and George) vary with the widest separation seen in 2004.

Even with low chum salmon tag recoveries at escapement projects, run timing data in 2004 showed similar results to 2002 and 2003 run timing patterns (Figure 22), where earlier tagged fish traveled further upstream than fish tagged later in the season (Kerkvliet et al. 2003, 2004). Two clusters of timings appear to represent the farthest migrating stocks (Takotna, Tatlawiksuk, and Kogrukluk) versus chum salmon from tributaries closer to the tagging site (George, Holokuk, and Aniak). Anomalous are the 17 voluntary tag recoveries from the Holitna River in 2003 with quite late run timing.

The 2004 curve representing the cumulative total catch of chum salmon at the Lower Kalskag fish wheels show a large depression caused by the high water levels experienced during the period in late June and early July, when the left bank wheel was moved to a less productive location. Past run timing analysis from this project show that stocks passing during this period consist mostly of upper drainage tributaries. It is believed that this water event caused stocks passing during this period to be misrepresented causing low numbers to be tagged and hence, recovered at upstream escapement projects. That would explain the low numbers recovered at the Kogrukluk and Tatlawiksuk rivers as well as the absence of tags recovered at the Takotna River.

A discrepancy exists between run timing estimates at Lower Kalskag of chum salmon tags recovered at the Aniak sonar site versus the tags recovered voluntarily (Figure 22). This difference may be due to two factors. The first may be that the Aniak River sonar only operates for the month of July, therefore skewing Lower Kalskag run timing from tag recovery data early as chum salmon still enter the Aniak River throughout August. Also, the recovery method of using a beach seine is less intensive, and done only a few times a week causing low and sporadic tag recoveries (McEwen 2005). The curve representing volunteer tag recoveries in the Aniak River would best represent the chum salmon run timing as these tags were recovered throughout the summer and into the fall when water levels drop.

Data from both voluntary recoveries and weir projects were used to estimate stock-specific run timing for coho salmon since 2002. Chronological differences in run timing by distance traveled are not as apparent for coho salmon (Figure 24) as for the other salmon species. Based on weir

project recoveries, Kerkvliet et al. (2003, 2004) noted that earlier tagged coho salmon traveled further upstream than fish tagged later in the season. For example, the Tatlawiksuk River tag recoveries had a median tag date earlier than the Kogrukluk River, and both of those earlier than the George River. In contrast, the median tag date of the Aniak River and Holitna River volunteer tag recoveries is much earlier than would be expected in relation to the distance from the tagging sites. In the opposite direction, volunteer tags recovered above the mouth of the Takotna River (17 in 2003, 9 in 2002) had a median tag date much later than any other tributary analyzed. It is unlikely that this is due to tag recovery effort as most subsistence and sport fishing along the Kuskokwim River is done earlier in the year to take advantage of more favorable weather.

Several project operation features and the biology of coho salmon could help explain the lack of chronological run timing. Coho salmon have extended run timing and the project does not necessary operate through the end of the run. Tag recovery at weirs ended the same time throughout the drainage although they are different distances from the tagging site. Volunteer tag recovery effort is also weighted towards the early part of salmon runs with more fishing effort directed toward Chinook than coho salmon, thus more likely to recover sockeye, chum or early run coho salmon tags than later running coho salmon. In the Aniak river, recovery also generally takes place early in the run (of all salmon species in general), skewing the median tag date early, or the fact that tags were no longer deployed on September 8 misrepresenting the entire Aniak River stock, and only tagging the beginning of it.

TRAVEL SPEED AND TRAVEL DAYS

Tag recovery data from escapement projects allowed us to assess travel speed of monitored stocks. To fully understand these types of data, one needs to be aware of potential biases when the behavior of tagged fish is not the same as untagged fish. There is ample literature indicating that initially after tagging, fish "sulk" (Bernard et al. 1999; Jones III et al. 2001). When sulking behavior is considered in estimating travel speed, the travel time of tagged fish would likely be slower than untagged fish.

Sockeye salmon tag recoveries of ample sizes have only occurred at the Kogrukluk River weir during the past 3 seasons. Travel speed was similar in 2003 and 2004 for sockeye salmon to the Kogrukluk River weir (t-test: t=1.777; df=94; P=0.079).

Chum salmon tag recoveries were low at the upstream escapement projects, resulting in only 2 tags being recovered at Kogrukluk River and none at the Takotna River. Travel speed was similar in 2003 and 2004 for chum salmon at the Aniak River sonar site (t-test: t = 0.147; df = 36; P = 0.884), and the George River weir (t-test: t=-1.377; df=275; P=0.170). Travel speed was similar as well at the Tatlawiksuk River weir (t-test: t = 0.525; df=112; P=0.600), between the years of 2002 and 2004, due to operations being shut down in 2003 at the Tatlawiksuk River weir. Results continue to suggest that fish traveling further upstream travel fasting than those traveling less distance, even with low sample sizes.

Travel speed of coho salmon was similar in 2003 and 2004 at the Kogrukluk River weir (t-test: t=2.807; df=951; p=0.005), and in 2002 and 2004 at the Tatlawiksuk River weir (t-test: t=1.222; df=126; p=0.224). It was not similar between 2003 and 2004 however, at the George River weir (t-test: t=-2.439; df=213; P=0.016), and the Takotna River weir (t-test: t=2.313; df=69; P=0.024). Travel speeds were slower this year of all the 3 years except for the George River weir. The George River weir only recovered 5 tags, and observed another 21. It could be that the 5

recovered tags were on fish that were less apprehensive to pass the weir during the record low water levels that were experienced this year, biasing towards a faster travel speed.

Comparisons of travel speed between early and late season coho salmon among years (2001–2004) was not possible. Difficulties occur when travel speeds are grouped as early run or late run fish, which do not provide the clear resolution between the two groups across all years. However, graphically displayed data and statistical analysis by year shows a difference between early and late run coho salmon, and the travel speed of later returning coho salmon increased. Differences in travel speed between early and late runs may be attributed to milling behavior similar to the findings of McPherson et al. (1998). Results from this study have shown that coho salmon that enter the stream early in the season exhibit milling behavior longer at the marking site than those that enter the stream later in the season. In 2004 however, the opposite was observed at the Tatlawiksuk River weir where, when graphically displayed, individual speeds seemed to decrease (Figure 27).

COHO SALMON ABUNDANCE ESTIMATE

Initial diagnostic analysis indicated there was a need for stratification to account for temporal variation. An increasing proportion of marked fish in fish wheels at the Aniak recovery site led to temporal stratification of the recapture probabilities. Two strata were used: an early season strata (July 11–August 21) and a late season strata (August 22–September 11). The Darroch model was used to accommodate the stratification. The increase in the proportion of marked coho in the recapture wheel is likely caused by a change in the efficiency of the capture or recapture wheels. Possible causes of efficiency changes include repositioning of the wheels, changing water levels and water clarity, and abundance of fish in the river. All of these effects were present throughout the season and the efficiency changes are most likely due to some effect combination. Another assumption of the Darroch model is marking does not affect the probability of recapture. Throughout the tenure of the mark–recapture project, coho salmon have been the only species to exhibit no tagging effect.

The estimate of total run abundance in 2004 (386,743) was substantially lower that 2003 and only slightly higher than that estimated in 2003 (Table 25). The relationship between 2003 and 2004 is mirrored in other escapement projects. In contrast, when comparing 2002 and 2004, some tributary escapement monitoring projects observed similar escapements (Tatlawiksuk River and Takotna River weirs) and all others were higher in 2004 with some being significantly higher (Kwethluk River, Tuluksak River, and George River weirs).

CONCLUSIONS

Tag Deployment and Recovery: The period of tag deployment encompassed the sockeye and chum salmon run in 2004. In contrast, catches of coho salmon were still strong and rising when fish wheels operations ceased September 8 at the Lower Kalskag site and September 10 at the Aniak site. Catch rates and fish wheel performance was disappointing at the Lower Kalskag tagging site. Due to water events early in the season, there was concern that sockeye and chum salmon were not tagged in proportion to abundance throughout their migration.

Stock-specific Run Timing: Earlier tagged chum and coho salmon traveled further upstream than fish tagged later in the season. This is a pattern seen since 2002.

Stock-specific Travel Speed: Travel speeds were similar between 2003 and 2004 for chum and sockeye salmon, and for coho salmon at the Tatlawiksuk and Kogrukluk rivers. Travel speed

was not similar between 2003 and 2004 for coho salmon at the George and Takotna rivers. Travel speed characteristics may provide insights into behavioral characteristics such as milling and homing.

Coho Salmon Abundance Estimate: Total run abundance was calculated for coho salmon using the Darroch estimates and recovery data from the Aniak site. The coho salmon estimate is thought to be a reasonable estimate of abundance above Lower Kalskag based on comparisons between escapement projects and the 2003 abundance estimate, representing that portion of the run vulnerable to significant harvest.

RECOMMENDATIONS

- Relocate the Lower Kalskag tagging site upstream of the village of Kalskag, where it was prior to 2004, because it will provide a site where fish wheels are known to work effectively, thus increasing catches.
- Operate an additional third fish wheel, positioned on the right bank to increase catch totals and sample sizes of stocks bound for upper drainage tributaries.
- Employ the use of anchor floy-tag guns to apply uniquely numbered anchor floy-tags to expedite the tagging process, allowing for more fish to be sampled.
- Expend consistent effort in gillnetting for tag deployment to include sockeye and chum salmon. Do not decrease the time spent drift gillnetting if fish wheel catches increase to a point beyond which staff can clear live boxes and need help from those gillnetting. Instead decrease the time spent capturing salmon with fish wheels. Given the differences in stock composition between the two gear types sample sizes need to remain high in the gill net component.
- Expend effort in recovering tags from tributaries with little or no tag recovery effort, to increase the number of stocks used in run timing analysis.
- Mitigate the crowding effect on fish health, we recommend our sampling schedule be adjusted to decrease the number of fish held in live boxes. Further assessment is needed to better define the upper limits in the number of fish that corresponds to this effect.
- Compare 2001 through 2004 data sets using current year (2005) insights gain in probability of recapture, run timing, and bank orientation.

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TABLES AND FIGURES

Table 1.–Distances of locations along the Kuskokwim River drainage in kilometers and miles, from the mouth and from Bethel.

Location [b]	Distance From River Mouth [a]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Popokamiut (Downstream boundary District 1)	(3)	(2)	(109)	(68)
Kuskokwim River Mouth [a]	0	0	(106)	(66)
Apokak Slough (Downstream boundary District 1)	5	0	(106)	(66)
Eek River	13	8	(93)	(58)
Eek (community)	46	29	(60)	(37)
Kwegooyuk	22	13	(85)	(53)
Kinak River	32	20	(74)	(46)
Tuntutuliak (community)	45	28	(61)	(38)
Kialik River	50	31	(56)	(35)
Fowler Island	68	42	(39)	(24)
Johnson River	77	48	(29)	(18)
Napakiak (community)	87	54	(19)	(12)
Napaskiak (community)	97	60	(10)	(6)
Oscarville (community)	97	60	(10)	(6)
Bethel (community)	106	66	0	0
Gweek River	135	84	29	18
Kwethluk River	131	82	25	16
Kwethluk (community)	132	82	26	16
Kwethluk River Weir	216	134	109	68
Akiachak (community)	143	89	37	23
Kasigluk River	150	93	43	27
Kisaralik River	151	94	45	28
Akiak (community)	161	100	55	34
Mishevik Slough,	183	114	77	48
Tuluksak River	192	119	85	53
Tuluksak (community)	192	120	86	54
Tuluksak River Weir	248	154	142	88
Nelson Island	190	118	84	52
Bogus Creek (Upstream Boundary District 1)	203	126	97	60
High Bluffs	233	145	127	79
Downstream Boundary District 2	262	163	156	97
Mud Creek Slough	267	166	161	100
Lower Kalskag	259	161	153	95

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Table 1.–Page 2 of 3.

Location [b]	Distance From River Mouth [a]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Kalskag (community)	263	163	157	97
Lower Kalskag Fish wheel (2004)	249	155	143	89
Kalskag Fish wheel (2002, 2003, and 2005)	270	168	163	102
Birchtree Fish wheel (Aniak Site; 2001 to 2004)	294	183	187	117
Aniak River	307	191	201	125
Aniak (community)	307	191	201	125
Aniak Receiver Site (upper)	310	191	201	125
Aniak Receiver Site (lower)	306	191	201	125
Aniak Sonar Site	323	201	217	135
Aniak Sonar Receiver Site	323	201	217	135
Chuathbaluk (community)	323	201	217	135
Upstream Boundary District 2	322	200	216	134
Kolmakof River	344	214	238	148
Napaimiut (community)	359	223	253	157
Holokuk River	362	225	256	159
Sue Creek	381	237	275	171
Oskawalik River	398	247	291	181
Crooked Creek (community)	417	259	311	193
Georgetown (community)	446	277	340	211
George River	446	277	340	211
George River Weir	453	281	347	215
George Receiver Site	453	281	347	215
Red Devil (community)	472	293	365	227
Red Devil Receiver Site	472	293	365	227
Sleetmute (community)	488	303	381	237
Holitna River	491	305	385	239
Hoholitna River	538	334	432	268
Chukowan River	709	441	603	375
Kogrukluk River	709	441	603	375
Kogrukluk River Weir	710	441	604	375
Kogrukluk Receiver Site	710	441	604	375
Stony River (community)	534	332	428	266
Stony River	536	333	430	267
Lime Village (community)	644	400	538	334

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Table 1.–Page 3 of 3.

Location [b]	Distance From River Mouth [a]		Distance from Bethel	
	Kilometer	Miles	Kilometer	Miles
Telaquana River	727	452	621	386
Telaquana Lake (outlet)	756	470	650	404
Swift River	560	348	454	282
Tatlawiksuk River	563	350	457	284
Tatlawiksuk River Weir	568	353	462	287
Tatlawiksuk Receiver Site	568	353	462	287
Devil's Elbow	599	372	492	306
Vinasale (abandoned community)	665	413	558	347
Takotna River	752	467	645	401
Takotna (community)	832	517	726	451
Takotna River Weir	835	519	729	453
Takotna Receiver Site	835	519	729	453
McGrath (community)	753	468	647	402
McGrath Receiver Site	753	468	647	402
Middle Fork	806	501	700	435
Big River	827	514	721	448
Pitka Fork	845	525	739	459
Medfra (community)	863	536	756	470
South Fork	869	540	763	474
East Fork	882	548	776	482
North Fork	884	549	777	483
Nikolai (community)	941	585	835	519
Swift Fork	1,078	670	972	604
Telida (community)	1,128	701	1,022	635
Highpower Creek	1,151	715	1,044	649
Headwaters South Fork	1,292	803	1,186	737
Headwaters North Fork	1,548	962	1,442	896

Note: Distances are determined using a computer version (Garmin Topo MapSource) of U.S. Geological Survey 1:100,000 scale maps. Routing is as if traveling by boat.

[a] The "mouth" of the Kuskokwim River is defined as the southern most tip of Eek Island (latitude N 60° 05.569, longitude W 162° 19.054), and is one of three points that define the downstream boundary of District 1.

[b] Locations not on the mainstem of the Kuskokwim River are listed as subordinate to the point of departure from the mainstem.

Table 2.–Number of sockeye salmon tagged at the Lower Kalskag site or examined for tags at the Aniak site, Kuskokwim River, 2004.

Site	Sockeye Salmon			
L. Kalskag	Tagged	Untagged	Recaptures	Total Catch
Left Bank [a]	710	31	25	766
Right Bank [b]	1,175	40	42	1,257
Gillnet	0	4	0	4
Total	1,885	75	67	2,027
Aniak	Tagged	Untagged	Recaptures	Total Catch
Left Bank [a]	0	787	99	886
Right Bank [b]	0	154	8	162
Gillnet	0	3	1	4
Total	0	944	108	1,052
Combined	Tagged	Untagged	Recaptures	Total Catch
Total	1,885	1,019	175	3,079

[a] Fish wheel anchored on left bank.

[b] Fish wheel anchored on right bank.

Table 3.–Number of chum salmon tagged at the Lower Kalskag site or examined for tags at the Aniak site, Kuskokwim River, 2004.

Site	Chum Salmon			
Lower Kalskag	Tagged	Untagged	Recaptures	Total Catch
Left Bank [a]	3,291	179	80	3,550
Right Bank [b]	1,985	153	136	2,274
Gillnet	0	72	0	72
Total	5,276	404	216	5,896
Aniak	Tagged	Untagged	Recaptures	Total Catch
Left Bank [a]	0	13,590	560	14,150
Right Bank [b]	0	3,763	70	3,833
Gillnet	0	98	2	100
Total	0	17,451	632	18,083
Combined	Tagged	Untagged	Recaptures	Total Catch
Total	5,276	17,855	848	23,979

[a] Fish wheel anchored on left bank.

[b] Fish wheel anchored on right bank.

Table 4.–Number of coho salmon tagged at the Lower Kalskag site or examined for tags at the Aniak site, Kuskokwim River, 2004.

Site	Coho Salmon			
Lower Kalskag	Tagged	Untagged	Recaptures	Total Catch
Left Bank [a]	950	15	22	987
Right Bank [b]	1,380	38	22	1,440
Gillnet	641	18	3	662
Total	2,971	71	47	3,089
Aniak	Tagged	Untagged	Recaptures	Total Catch
Left Bank [a]	0	4,095	36	4,131
Right Bank [b]	0	5,629	44	5,673
Gillnet	0	739	1	740
Total	0	10,463	81	10,544
Combined	Tagged	Untagged	Recaptures	Total Catch
Total	2,969	10,534	128	13,631

[a] Fish wheel anchored on left bank.

[b] Fish wheel anchored on right bank.

Table 5.–Number of tagged sockeye salmon recovered or observed at tributary escapement projects located downstream and upstream from the Lower Kalskag tagging site, Kuskokwim River, 2004.

Distance from Tag Sites (rkm) [a]	Location	Total Count	Lower Kalskag				Tag Summary Ratio [e]
			F [b]	G [c]	U [d]	Total	
-177	Kwethluk R.	3,303	5	0	1	6	0.002
-87	Tuluksak R.	136	2	0	0	2	0.015
74	Aniak R.	46	1	0	0	1	0.022
204	George R.	177	13	0	1	14	0.079
319	Tatlawiksuk R.	10	2	0	1	3	0.300
461	Kogrukluk R.	6,767	31	0	2	33	0.005
586	Takotna R.	17	1	0	0	1	0.059

[a] Negative distance means downstream from the tag sites. Distance indicated is from the Lower Kalskag site.

[b] Tagged from fish wheels.

[c] Tagged from gillnets.

[d] Capture gear unknown; tags observed but not recovered.

[e] Ratio = Total number of tags recovered and observed/Total count at escapement project.

Table 6.–Number and percent of tagged sockeye salmon recovered at tributary escapement projects by gear type used at the Lower Kalskag site, Kuskokwim River, 2004.

Recovery Source	Distance (rkm) [b]	Lower Kalskag						
		Fish Wheel				Drift Gillnets		Total [a]
		Right Bank		Left Bank				
		n	% [c]	n	% [c]	n	% [c]	n
Tagged at L. Kalskag	0	1,175	62	710	38	0	0	1,885
Aniak R. Sonar [d]	74	0	0	1	100	0	0	1
George R. Weir	204	11	85	2	15	0	0	14
Tatlawiksuk R. Weir	319	0	0	2	100	0	0	3
Kogrukluk R. Weir	461	24	77	7	23	0	0	33
Takotna R. Weir	586	0	0	1	100	0	0	1
Upstream Total		35	73	13	27	0	0	52
Kwethluk R. Weir	-177	3	60	2	40	0	0	6
Tuluksak R. Weir	-87	1	50	1	50	0	0	2

[a] Includes tags for which tagging gear and site is unknown (tag observed but not recovered). Percent by location based only on recovered tags.

[b] Negative distance means downstream from the tag sites. Distance indicated is from the Lower Kalskag site.

[c] By recovery location the percent recoveries that were tagged from this location and gear.

[d] Represents tags recovered during beach seining for ASL samples.

Table 7.–Number of tagged sockeye salmon recovered by subsistence, commercial, and sport fishers in relation to the distance from the Lower Kalskag tagging site, Kuskokwim River, 2004.

Distances from Tag Sites (rkm) [a, b]	Tags Recovered				
	Subsistence	Commercial	Sport	Found	Total
< -60	32	13	3	0	48
-60 to 60	12	0	0	0	12
> 60	21	1	2	8	32
	0	0	0	0	0
Total	65	14	5	8	92

[a] Negative distance means downstream from the tag sites.

[b] Range of distances of recaptured fish.

Table 8.–Number of tagged chum salmon recovered or observed at tributary escapement projects located downstream and upstream from the Lower Kalskag tagging site, Kuskokwim River, 2004.

Distance from Tag Sites (rkm) [a]	Location	Total Count	Lower Kalskag				Tag Summary
			F [b]	G [c]	U [d]	Total	Ratio [e]
-177	Kwethluk R.	37,114	2	0	1	3	<0.001
-87	Tuluksak R.	11,796	14	0	2	16	0.001
74	Aniak R.	2,143	5	0	0	5	0.002
204	George R.	13,058	58	0	4	62	0.005
319	Tatlawiksuk R.	24,174	7	0	1	8	<0.001
461	Kogrukluk R.	21,245	2	0	1	3	<0.001
	Total	109,530	88	0	9	97	0.001

[a] Negative distance means downstream from the tag sites. Distance indicated is from the Lower Kalskag site.

[b] Tagged from fish wheels.

[c] Tagged from gillnets.

[d] Capture gear unknown; tags observed but not recovered.

[e] Ratio = Total number of tags recovered and observed/Total count at escapement project.

Table 9.–Number and percent of tagged chum salmon recovered at tributary escapement projects by capture gear type used at the Lower Kalskag site, Kuskokwim River, 2004.

		Lower Kalskag						
		Fish Wheel				Drift Gillnets		Total [a]
	Distance	Right Bank		Left Bank				
Recovery Source	(rkm) [b]	n	% [c]	n	% [c]	n	% [c]	n
Tagged at L. Kalskag	0	1,985	38	3,291	62	0	0	5,276
Aniak R. Sonar [d]	74	0	0	5	100	0	0	5
George R. Weir	204	36	62	22	38	0	0	62
Tatlawiksuk R. Weir	319	6	86	1	14	0	0	8
Kogrukluk R. Weir	461	2	100	0	0	0	0	3
Upstream Total		44	61	28	39	0	0	78
Kwethluk R. Weir	-177	0	0	2	100	0	0	3
Tuluksak R. Weir	-87	3	21	11	79	0	0	16

[a] Includes tags for which tagging gear and site is unknown (tag observed but not recovered). Percent by location based only on recovered tags.

[b] Negative distance means downstream from the tag sites. Distance indicated is from the Lower Kalskag site.

[c] By recovery location the percent recoveries that were tagged from this location and gear.

[d] Represents tags recovered during beach seining for ASL samples.

Table 10.–Number of tagged chum salmon recovered by subsistence, commercial, and sport fishers in relation to the distance from the Lower Kalskag tagging site, Kuskokwim River, 2004.

Distances from Tag Sites (rkm) [a,b]	Tags Recovered				
	Subsistence	Commercial	Sport	Found	Total
< -60	28	13	0	0	41
-60 to 60	24	0	2	4	30
> 60	8	0	1	61	70
Unknown	0	0	0	0	0
Total	60	13	3	65	141

[a] Negative distance means downstream from the tag sites.

[b] Range of distances of recaptured fish.

Table 11.–Number of tagged coho salmon recovered or observed at tributary escapement projects located downstream and upstream from the Lower Kalskag tagging site, Kuskokwim River, 2004.

Distance from Tag Sites (rkm) [a]	Location	Total Count	Lower Kalskag				Tag Summary
			F [b]	G [c]	U [d]	Total	Ratio [e]
-87	Tuluksak R.	20,336	1	1	1	3	<0.001
204	George R.	13,248	4	1	16	21	0.002
319	Tatlawiksuk R.	26,078	28	5	2	35	0.001
461	Kogrukluk R.	16,410	21	10	23	54	0.003
586	Takotna R.	3,207	5	0	0	5	0.002
	Total	79,279	59	17	42	118	0.001

[a] Negative distance means downstream from the tag sites. Distance indicated is from the Lower Kalskag site.

[b] Tagged from fish wheels.

[c] Tagged from gillnets.

[d] Capture gear unknown; tags observed but not recovered.

[e] Ratio = Total number of tags recovered and observed/Total count at escapement project.

Table 12.–Number and percent of tagged coho salmon recovered at tributary escapement projects by capture gear type used at the Lower Kalskag site, Kuskokwim River, 2004.

Recovery Source	Distance (rkm) [b]	Lower Kalskag						
		Fish Wheel						
		Right Bank		Left Bank		Drift Gillnets		Total [a]
		n	% [c]	n	% [c]	n	% [c]	n
Tagged at L. Kalskag	0	1,380	46	950	32	641	22	2,971
George R. Weir	204	3	60	1	20	1	20	21
Tatlawiksuk R. Weir	319	16	52	5	16	10	32	54
Kogrukluk R. Weir	461	24	73	4	12	5	15	35
Takotna R. Weir	586	5	100	0	0	0	0	5
Upstream Total		48	65	10	14	16	22	115
Tuluksak R. Weir	-87	0	0	1	50	1	50	3

[a] Includes tags for which tagging gear and site is unknown (tag observed but not recovered). Percent by location based only on recovered tags.

[b] Negative distance means downstream from the tag sites. Distance indicated is from the Lower Kalskag site.

[c] By recovery location the percent recoveries that were tagged from this location and gear.

Table 13.–Number of tagged coho salmon recovered by subsistence, commercial, and sport fishers in relation to the distance from the Lower Kalskag tagging site, Kuskokwim River, 2004.

Distances from Tag Sites (rkm) [a,b]	Tags Recovered				
	Subsistence	Commercial	Sport	Found	Total
< -60	12	24	0	1	37
-60 to 60	30	0	11	1	42
> 60	8	0	14	4	26
	0	0	0	0	0
Total	50	24	25	6	105

[a] Negative distance means downstream from the tag sites.

[b] Range of distances of recaptured fish.

Table 14.–Run timing of sockeye salmon tagged at the Lower Kalskag tagging site (median tag date) and recaptured (median recapture date) at tributary escapement projects, Kuskokwim River, 2004.

Location (Distance from Lower Kalskag Site (rkm))	Total Count	Median Date	Lower Kalskag Tag Recoveries		
				Median Dates	
			n	Tagged	Recovered
George R. (204)	177	8/12	13	8/01	8/09
Tatlawiksuk R. (319)	10	8/11	2	7/21	8/02
Kogrukluk R (461)	6,767	7/12	31	6/29	7/26

Table 15.–Run timing of chum salmon tagged at Lower Kalskag (median tag date) and recaptured (median recapture date) at tributary escapement projects, Kuskokwim River, 2004.

Location (Distance from the Lower Kalskag site (rkm))	Catch	Median Date	Lower Kalskag Recaptures		
				Median Dates	
			n	Tag	Recaptures.
Aniak R. (74)	2,143	7/15	5	7/22	7/28
George R. (204)	13,058	7/11	58	7/17	7/24
Tatlawiksuk R. (319)	24,174	7/14	7	7/01	7/10
Kogrukluk R (461)	21,245	7/14	2	6/30	7/16

Table 16.–Run timing of coho salmon tagged at Lower Kalskag (median tag date) and recaptured (median recapture date) at Aniak or tributary escapement projects, Kuskokwim River, 2004.

Location (Distance from the Lower Kalskag site (rkm))	Catch	Median Date	Kalskag Recaptures		
				Median Dates	
			n	Tag	Recap.
Aniak Site (45)	10,544	8/14	81	8/16	8/22
George R. (204)	13,248	8/31	5	8/21	9/03
Tatlawiksuk R. (319)	26,078	8/19	33	8/12	8/31
Kogrukluk R (461)	16,410	8/31	31	8/16	9/08
Takotna R. (586)	3,207	8/26	5	8/02	8/21

Table 17.–Sockeye salmon travel speed (rkm/day) based on tag recoveries at the Aniak tag recovery site and at tributary escapement projects, Kuskokwim River, 2004.

Tag Recoveries	Tag Dates	N	Travel Speed (rkm/day)		Travel Days	
			Mean	SD	Mean	Range
Aniak Site	Jul. 9 – Aug. 31	108	21	12.0	3	1-22
Aniak R. Sonar	Jul. 1	1	11		7	7
George R. Weir	July 17 – Aug. 29	13	27	6.4	8	6-16
Tatlawiksuk R. Weir	July 16 – July 26	2	27	7.5	13	10-15
Kogrukluk R. Weir	June 16 – July 22	31	22	5.9	22	13-38
Takotna R. Weir	July 22	1	23		25	25

Table 18.–Chum salmon travel speed (rkm/day) based on recoveries at the Aniak tag recovery site and at tributary escapement projects, Kuskokwim River, 2004.

Tag Recoveries	Tag Dates	N	Travel Speed (rkm/day)		Travel Days	
			Mean	SD	Mean	Range
Aniak Site	July 15 – Sept. 6	630	24	10.6	2	1-35
Aniak R.	July 20 – July 25	5	17	7.2	5	3-7
George R.	June 26 – Aug. 30	58	29	5.7	7	4-14
Tatlawiksuk R.	June 27 – Sept. 7	7	35	4.1	9	8-11
Kogrukluk R.	June 27 – July 4	2	31	10.9	16	12-20

Table 19.–Coho salmon travel speed (rkm/day) based on recoveries at the Aniak tag recovery site and at tributary escapement projects, Kuskokwim River, 2004.

Tag Recoveries	Tag Dates	N	Travel Speed (rkm/day)		Travel Days	
			Mean	SD	Mean	Range
Aniak Tag Site	July 12 – Sept. 8	81	14	8.7	5	1-25
George R.	Aug. 11 – Aug. 29	5	21	8.1	11	6-15
Tatlawiksuk R.	July 28 – Aug. 29	33	18	4.6	19	12-37
Kogrukluk R.	Aug. 3 – Sept. 5	31	23	5.4	21	13-32
Takotna R.	July 24 – Aug. 10	5	26	2.8	23	19-24

Table 20.–Number of coho salmon examined for secondary marks at the George, Kogrukluk, Tatlawiksuk, and Takotna River weirs, Kuskokwim River, 2004.

Escapement Project	Coho Salmon	
	Examined [a]	Tag Loss [b]
George River weir	220	0
Tatlawiksuk River weir	353	0
Kogrukluk River weir	210	0
Takotna River weir	448	0
Total	1,231	0

[a] Number of fish examined for secondary marks.

[b] Fish examined that had a secondary mark and were untagged.

Table 21.–Number of coho salmon tagged at the Lower Kalskag site and recaptured at the Aniak site by stratum, Kuskokwim River, 2004.

Tagging Stratum	Recovery Stratum		Total Recovered	Tags Released
	07/11-08/21	08/22-09/11		
07/11-09/11	38	43	81	2,971
Unmarked Catch	5,384	5,079		

Table 22.–Coho salmon total run abundance upstream of Lower Kalskag and probability of capture estimates from the Darroch model, Kuskokwim River, 2004.

Abundance Estimate	Standard Error	Probability of Capture	Standard Error
386,743	42,806	0.0077	0.0009
95% CI (303,995; 469,492)			

Table 23.–Estimates of sockeye salmon at various tributary projects and statistics from the Kuskokwim River tagging project, Kuskokwim River, 2002–2004.

Project	Distance from Tag sites (rkm)	2002	2003	2004
Kwethluk R. weir	-177	272	2,928	3,303
Kuskokwim R. [a] (Upstream of Kalskag)	0		90,449 (95% CI: 54,842; 126,056)	
Kalskag Tagging site [b]	0	295	1,478	1,885
Tags recovered at weirs/sonar [c]		14	61	60
Kogrukluk R. weir	461	4,050	9,164	6,767

[a] Kuskokwim River mark–recapture project total run estimate upstream of Kalskag.

[b] Catch from fish wheels and gillnets combined.

[c] Includes tag recoveries at weirs that range from rkm 74 to 586.

Table 24.–Estimates of chum salmon at various tributary projects and statistics from the Kuskokwim River tagging project, Kuskokwim River, 2002–2004.

Project	Distance from Tag sites (rkm)	2002	2003	2004
Kwethluk R. weir	-177	35,854	41,812	38,646
Tuluksak R. weir	-87	9,958	11,724	11,796
Kuskokwim R. [a] (Upstream of Kalskag)	0	675,659 (95% CI: 559,564; 797,955)	412,443 (95% CI: 351,765; 473,121)	
Kalskag tagging site [b]	0	7,288	9,732	5,896
Tags Recovered weir/sonar [c]		179	302	97
Aniak R. sonar	74	360,075	363,396	673,444 [d]
George R. weir	204	6,543	33,666	14,411
Tatlawiksuk R. weir	319	24,542	----	21,245
Kogrukluk R. weir	461	51,570	23,411	24,201
Takotna R. weir	586	4,366	3,393	1,633

[a] Kuskokwim River mark–recapture project total run estimate upstream of Kalskag.

[b] Catch from fish wheels and gillnets combined.

[c] Includes tag recoveries at weirs that range from rkm 74 to 586.

[d] Count is from the first year using DIDSON equipment and the estimate could be up to 20% higher than in previous years (McEwen 2005).

Table 25.–Estimates of coho salmon at various tributary projects of the Kuskokwim River and the Kuskokwim River tagging project, 2002–2004.

Project	Distance from Tag sites (rkm)	2002	2003	2004
Kwethluk R. weir	-177	23,298	107,789	64,216
Tuluksak R. weir	-87	11,487	41,071	20,336
Kuskokwim R. [a] (Upstream of Kalskag)	0	316,068 (95%CI:193,877; 438,259)	849,494 (95% CI: 654,182; 1,044,806)	386,743 (95% CI: 303,995; 469,492)
Kalskag tagging site [b]	0	3,075	7,288	3,08
Tags recovered at weirs/soar	---	249	850	118
George R. weir	204	6,759	33,280	13,248
Tatlawiksuk R. weir	319	11,363	----	16,410
Kogrukluk R. weir	461	14,516	74,754	27,041
Takotna R. weir	586	3,984	7,171	3,207

[a] Kuskokwim River mark–recapture project total run estimate upstream of Kalskag.

[b] Catch from fish wheels and gillnets combined.

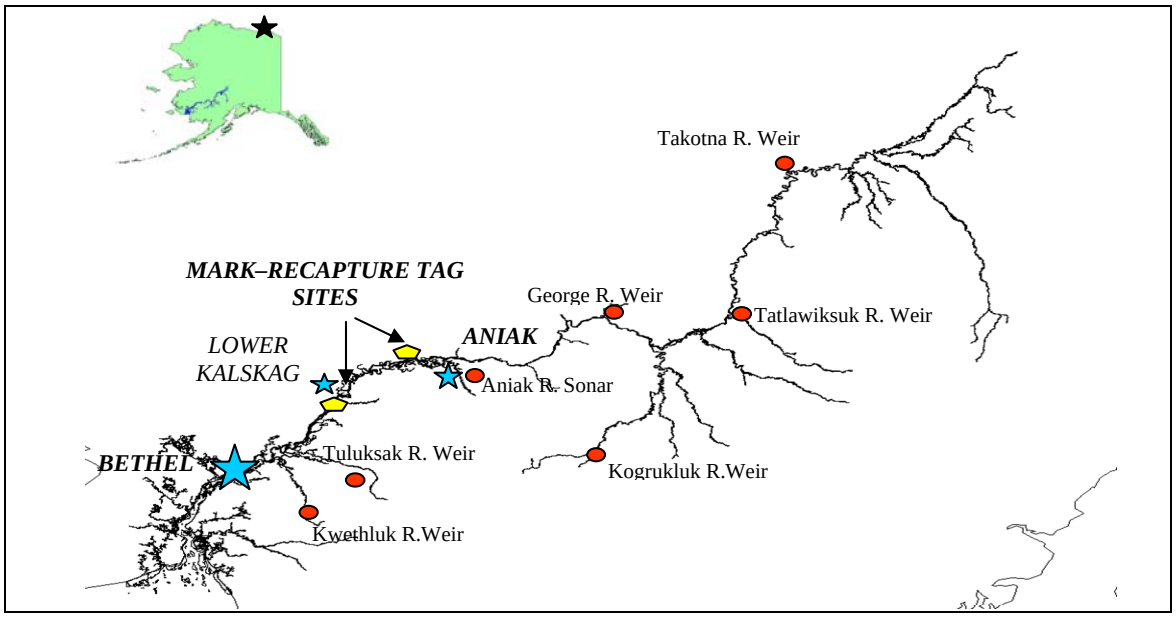


Figure 1.–Locations of tagging and weir sites, Kuskokwim River, 2004.

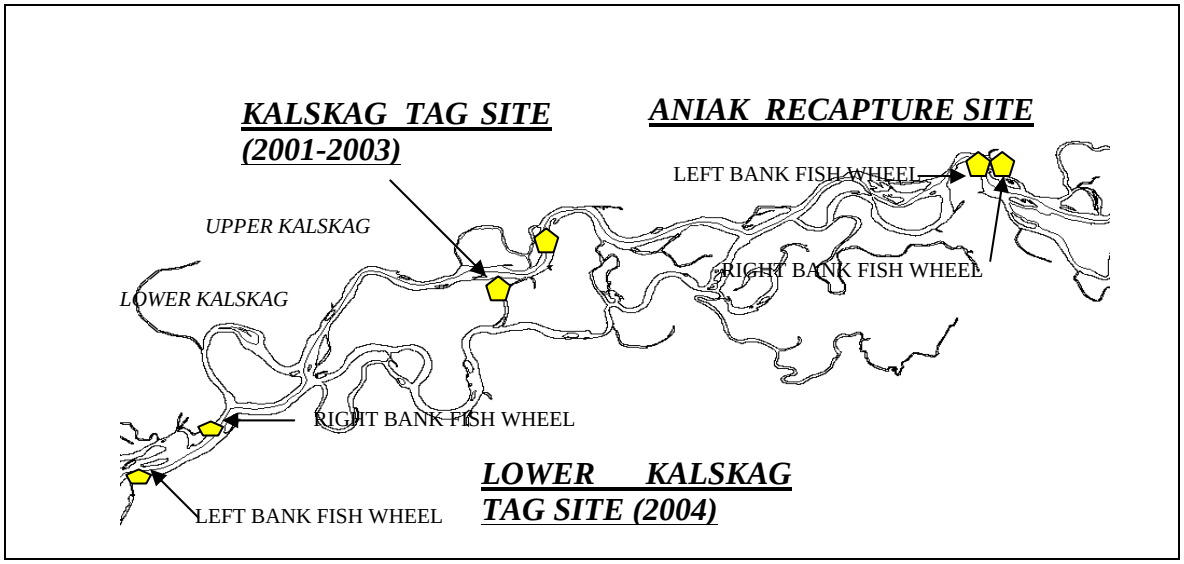


Figure 2.–Locations of fish wheels at tagging/recapture sites, Kuskokwim River, 2001–2004.

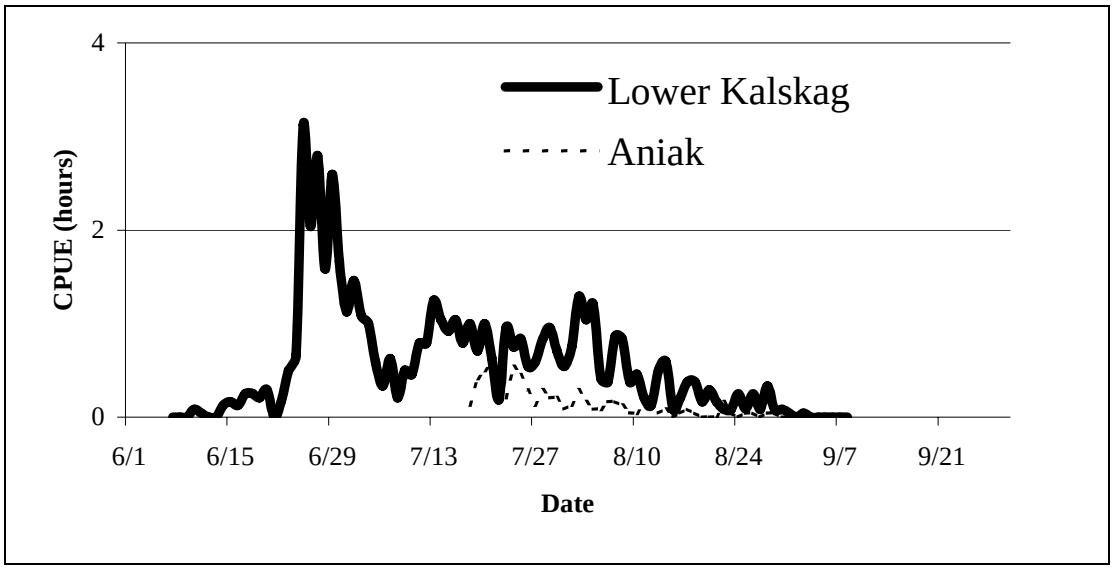


Figure 3.–Catch per hour of sockeye salmon from right bank fish wheels at the Lower Kalskag and Aniak fish wheel sites, Kuskokwim River, 2004.

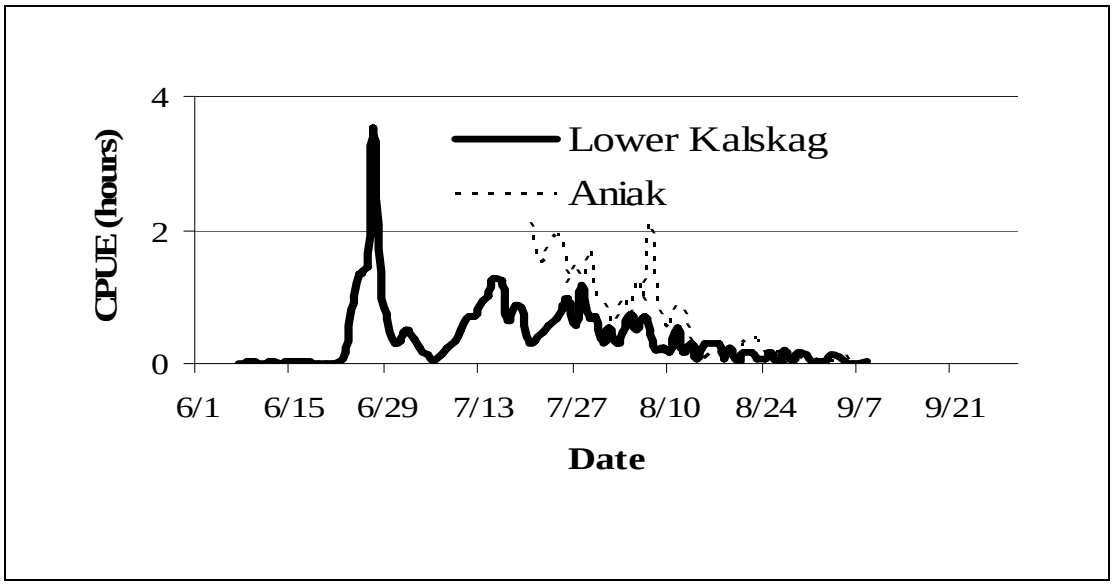


Figure 4.–Catch per hour of sockeye salmon from left bank fish wheels at the Lower Kalskag and Aniak fish wheel sites, Kuskokwim River, 2004.

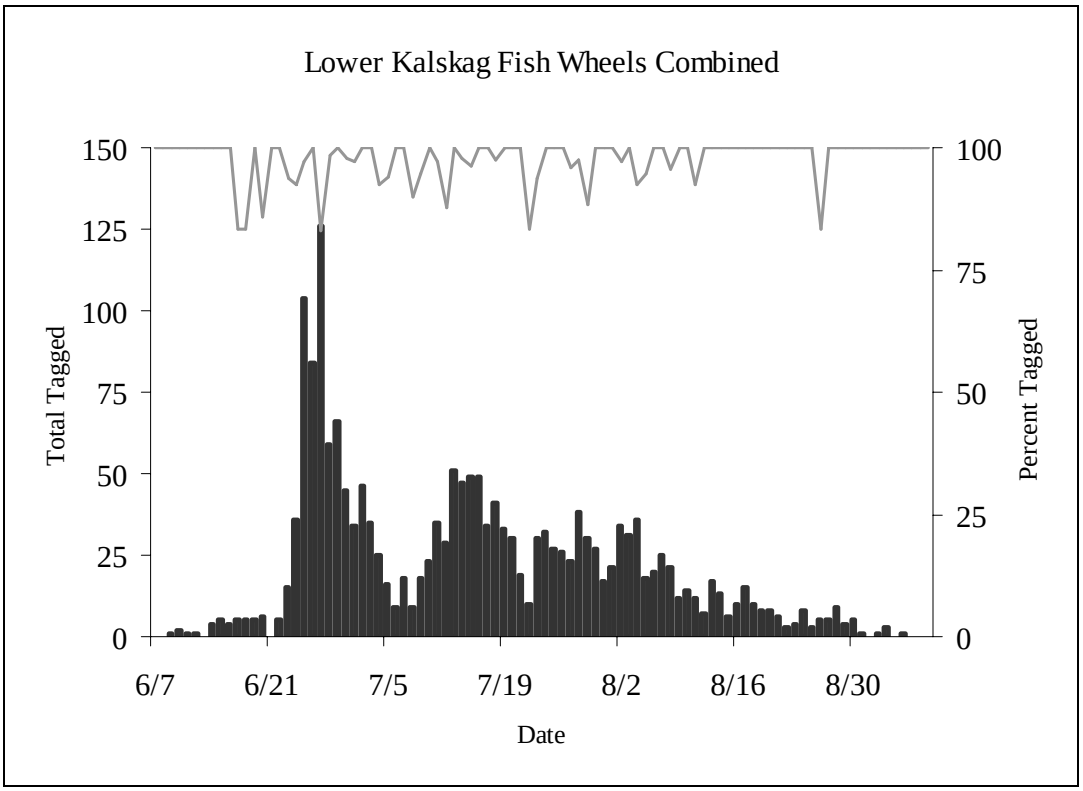


Figure 5.–Number of sockeye salmon tagged by date compared to the percent of sockeye salmon tagged at the Lower Kalskag site, Kuskokwim River, 2004.

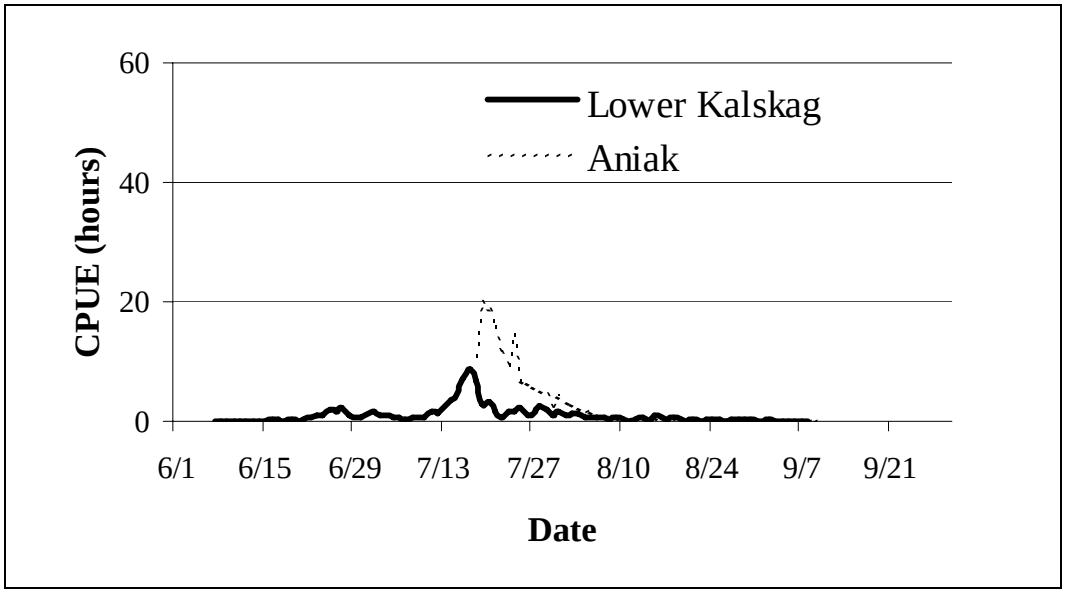


Figure 6.–Catch per hour of chum salmon from right bank fish wheels at the Lower Kalskag and Aniak fish wheel sites, Kuskokwim River, 2004.

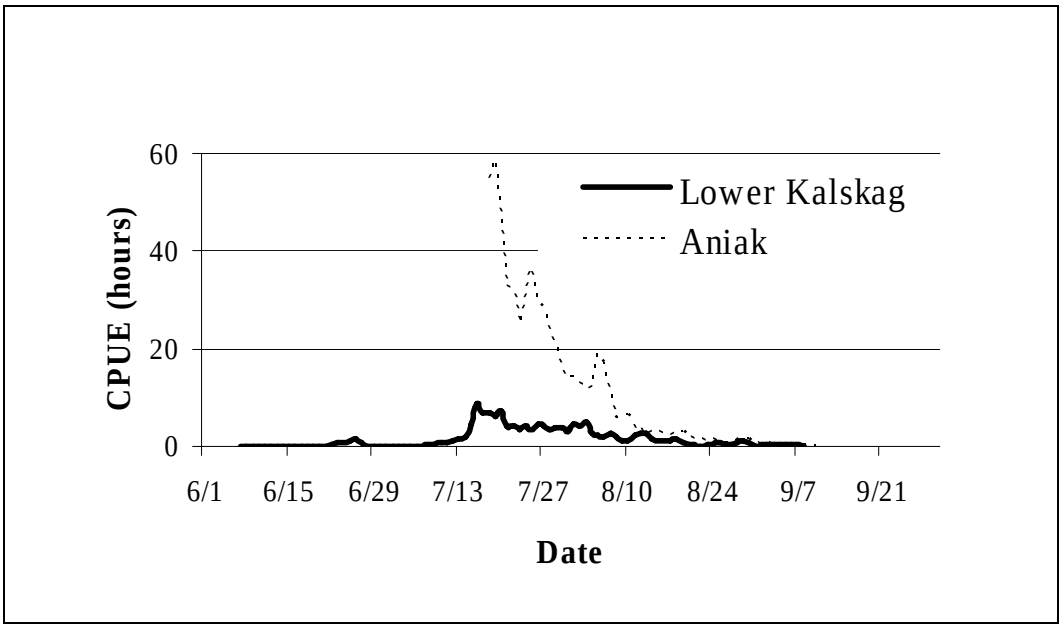


Figure 7.–Catch per hour of chum salmon from left bank fish wheels at the Lower Kalskag and Aniak fish wheel sites, Kuskokwim River, 2004.

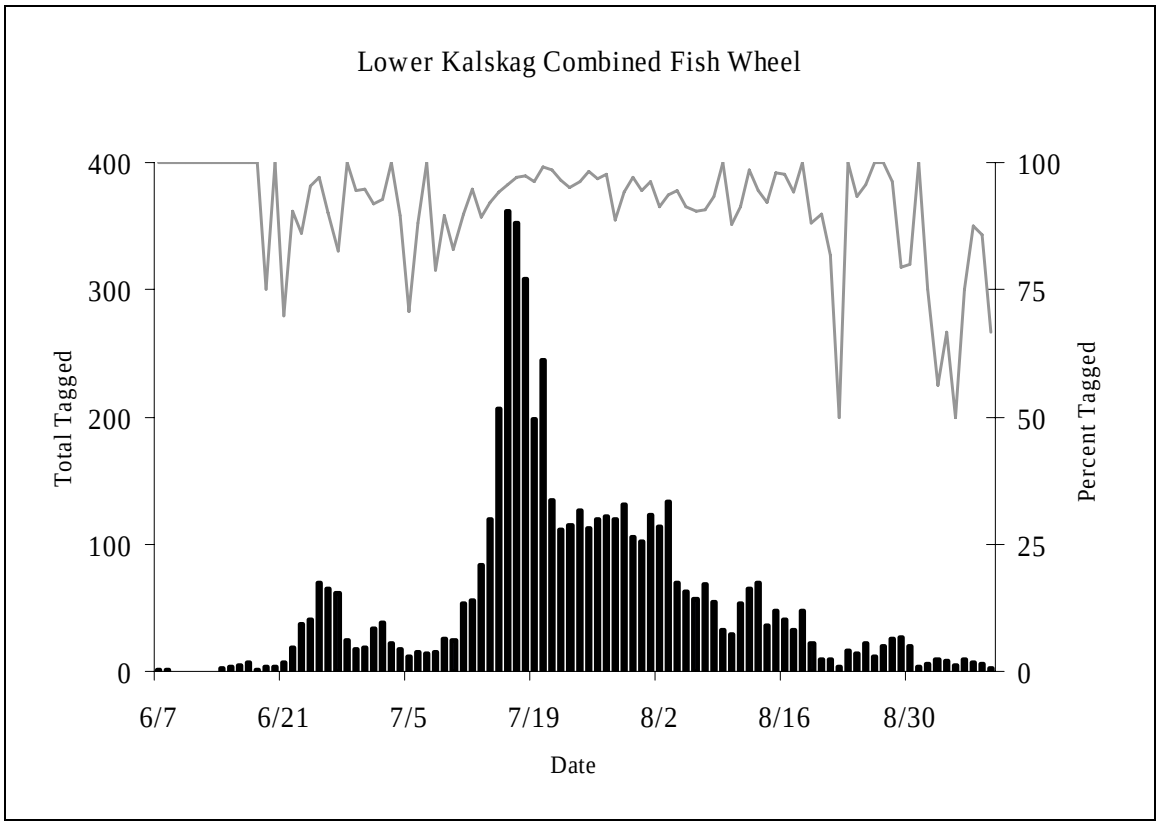


Figure 8.–Number of chum salmon tagged by date compared to the percent of chum salmon tagged at the Lower Kalskag site, Kuskokwim River, 2004.

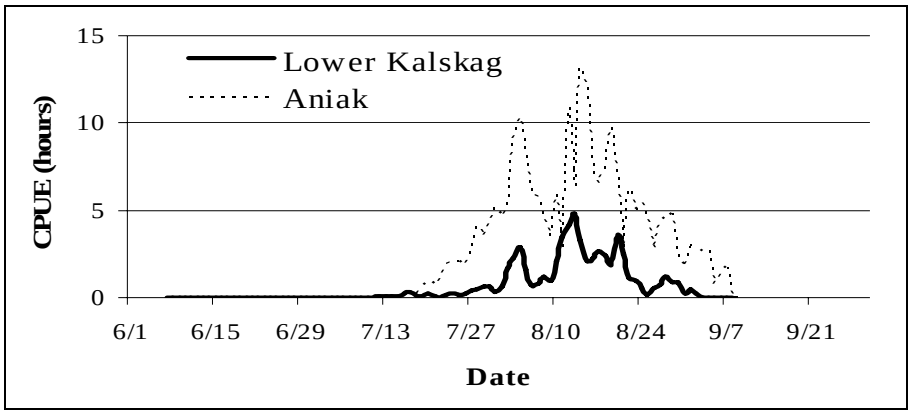


Figure 9.–Catch per hour of coho salmon from right bank fish wheels at the Lower Kalskag and Aniak fish wheel sites, Kuskokwim River, 2004.

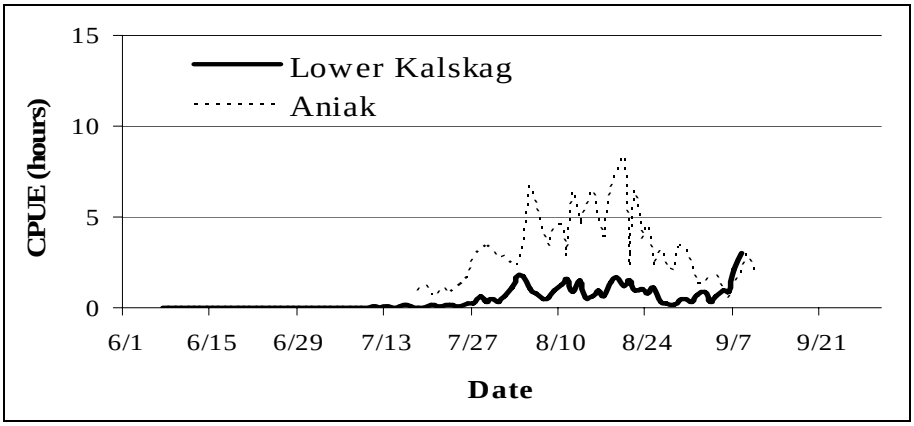


Figure 10.–Catch per hour of coho salmon from left bank fish wheels at the Lower Kalskag and Aniak fish wheel sites, Kuskokwim River, 2004.

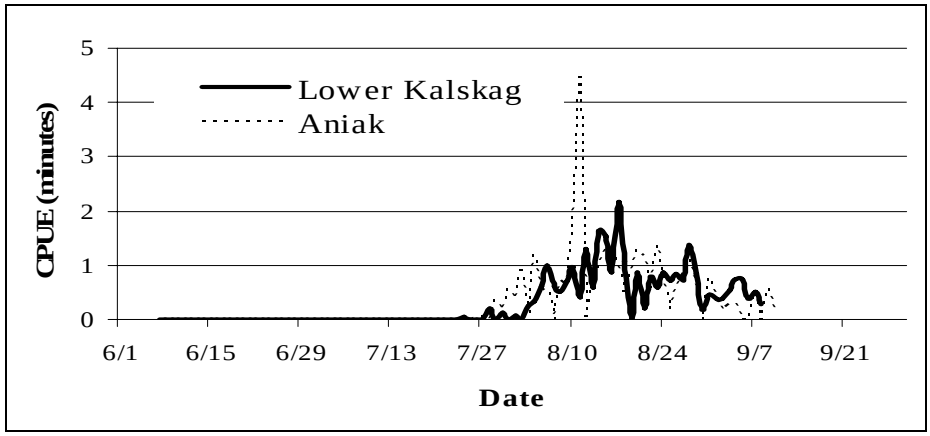
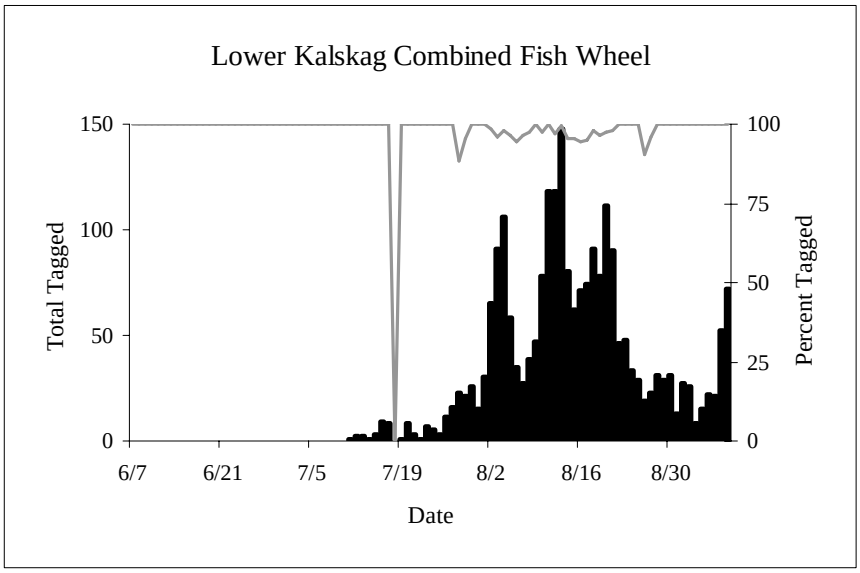


Figure 11.–Catch per hour of coho salmon from drift gillnets at the Lower Kalskag and Aniak fish wheel sites, Kuskokwim River, 2004.



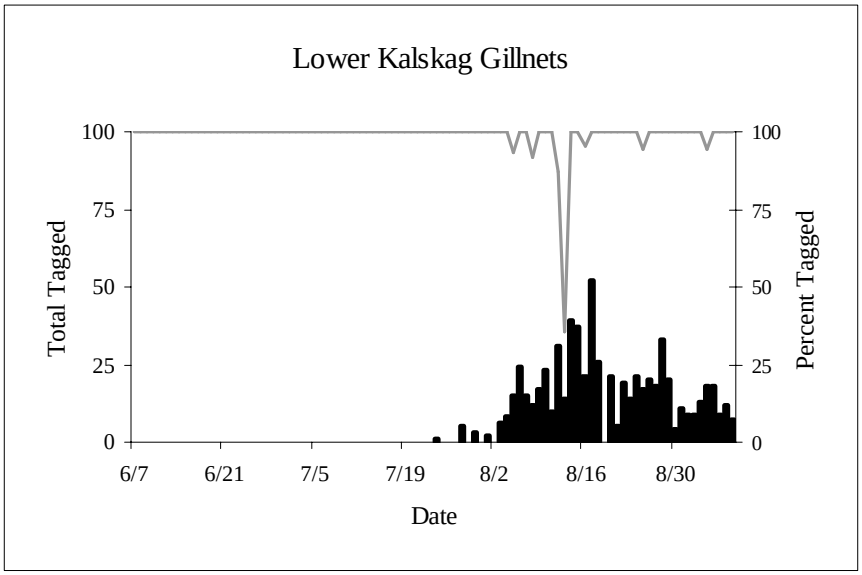


Figure 12.–Number of coho salmon tagged by date compared to the percent of coho salmon tagged at the Lower Kalskag site, Kuskokwim River, 2004.

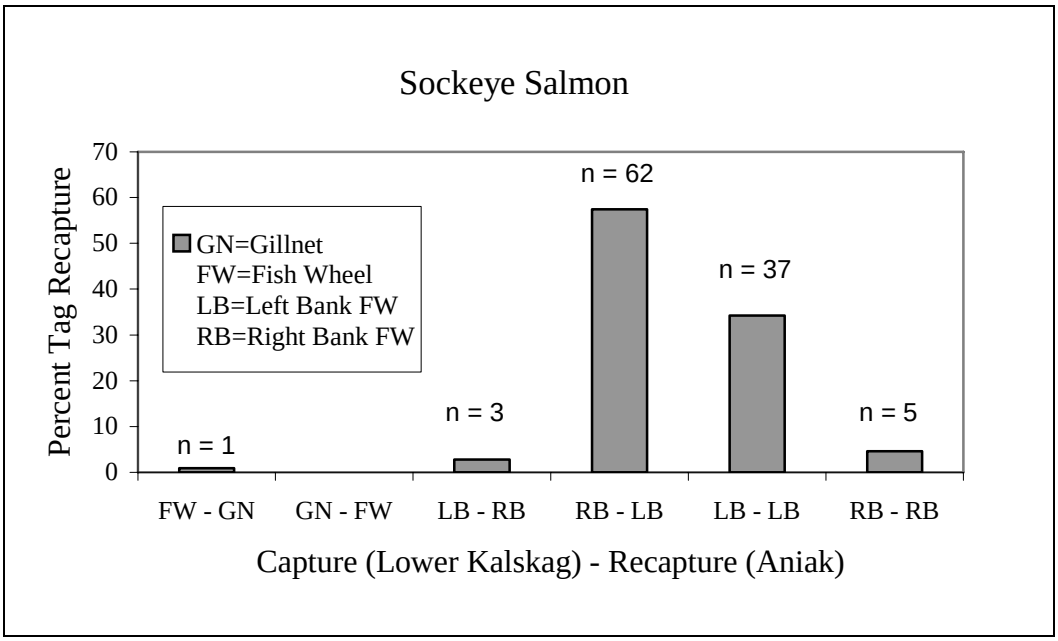


Figure 13.–Percentage of sockeye salmon tagged at the Lower Kalskag site and recaptured at the Aniak site, using fish wheels or drift gillnets, Kuskokwim river, 2004.

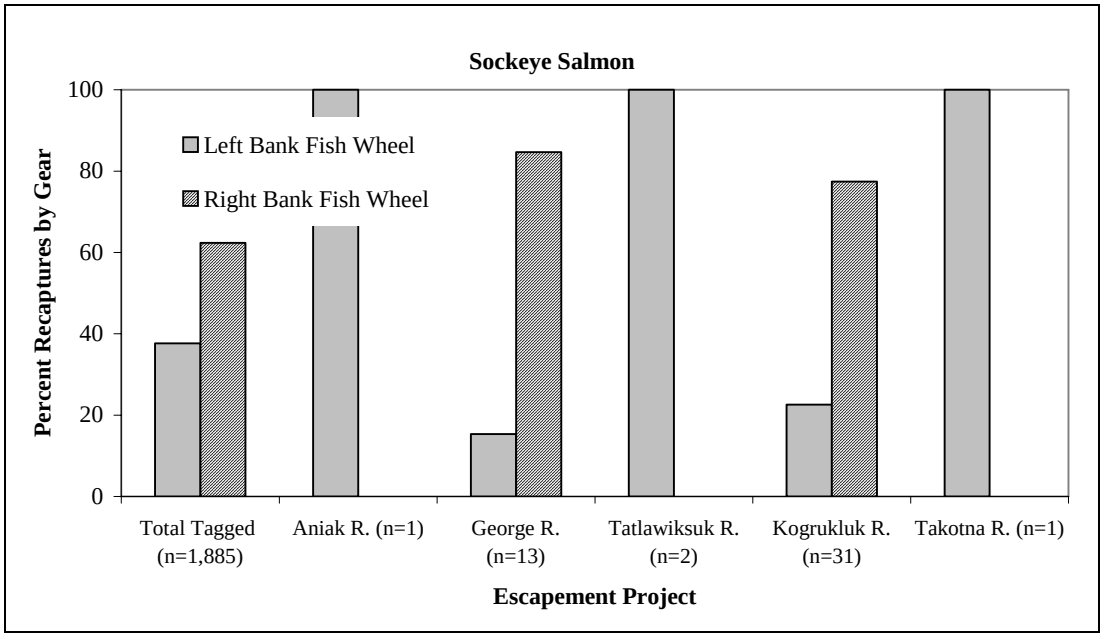


Figure 14.–Percent recaptures of sockeye salmon tagged at the Lower Kalskag site from right and left bank fish wheels and recovered at tributary escapement projects, Kuskokwim River, 2004.

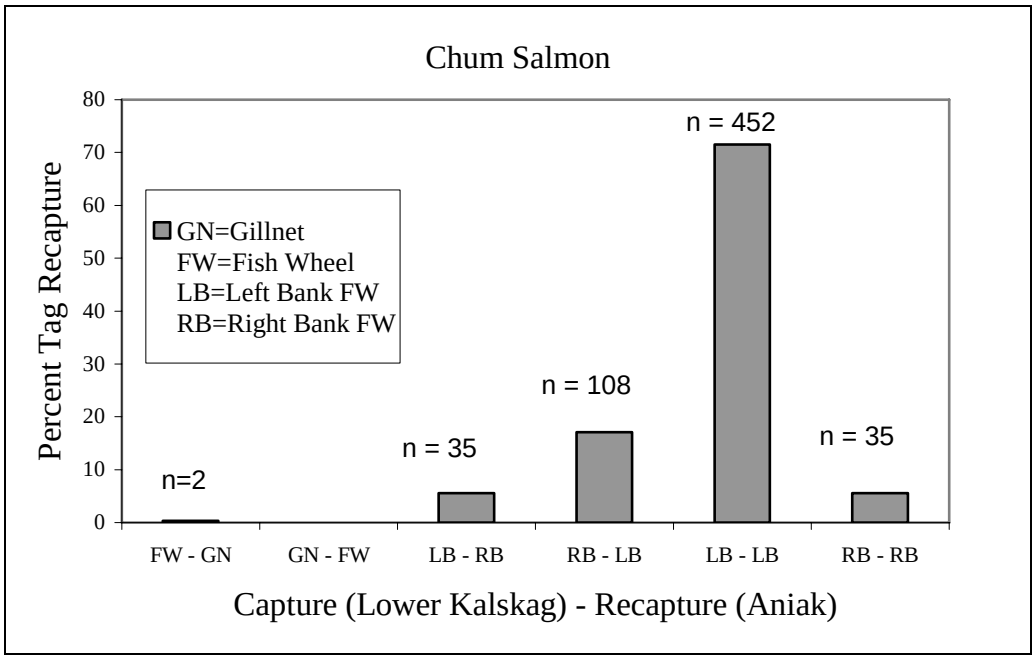


Figure 15.–Percentage of chum salmon tagged at the Lower Kalskag site and recaptured at the Aniak site using fish wheels or gillnets, Kuskokwim River, 2004.

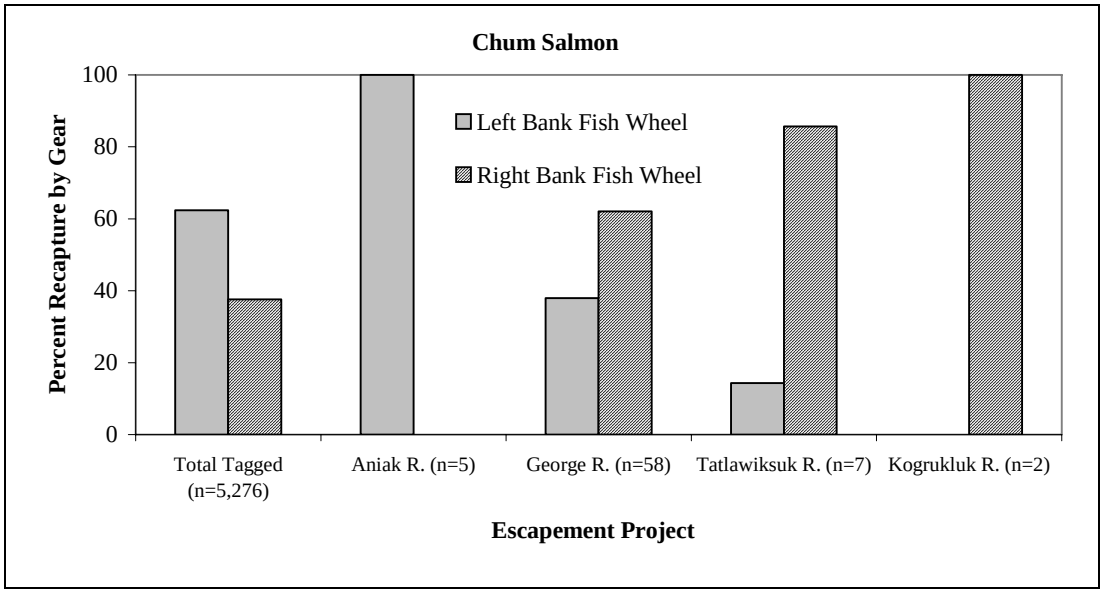


Figure 16.–Percentage of chum salmon tagged at the Lower Kalskag site from gillnets, right and left bank fish wheels and recovered at tributary escapement projects, Kuskokwim River, 2004.

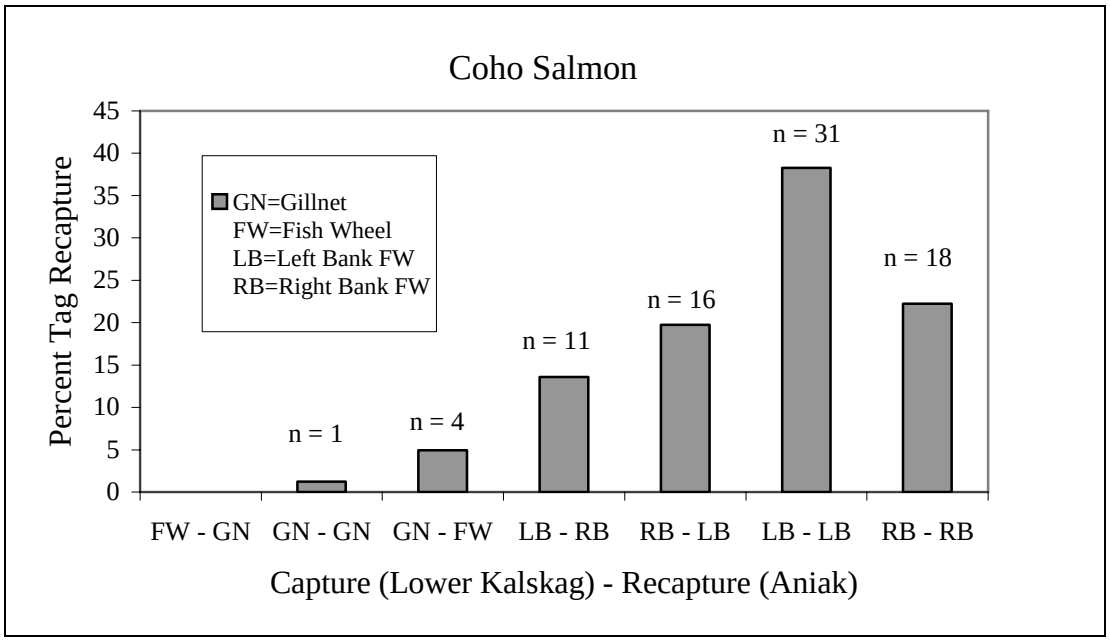


Figure 17.–Percentage of coho salmon tagged at the Lower Kalskag site and recaptured at the Aniak site using fish wheels or gillnets, Kuskokwim River, 2004.

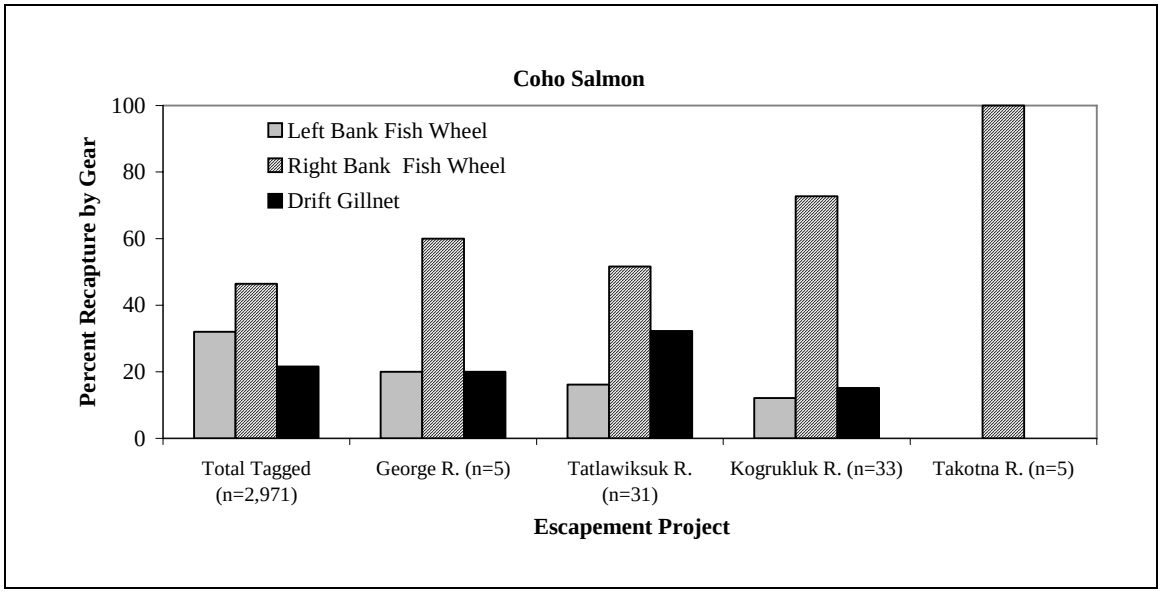


Figure 18.–Percentage of coho salmon tagged at the Lower Kalskag site from gillnets, right and left bank fish wheels and recovered at tributary escapement projects, Kuskokwim River, 2004.

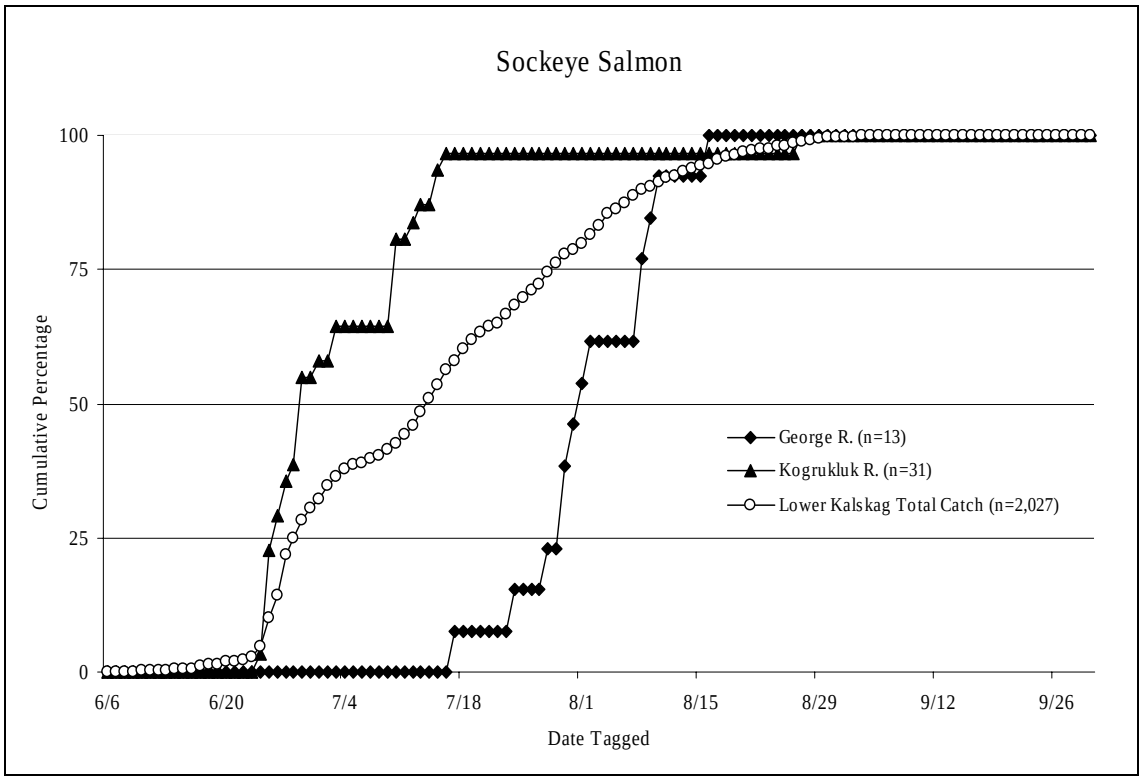


Figure 19.–Cumulative percentage of recaptured sockeye salmon at the George and Kogrukluk River weirs by date of tagging, and the total number of sockeye salmon captured at the Lower Kalskag tag site, Kuskokwim River, 2004.

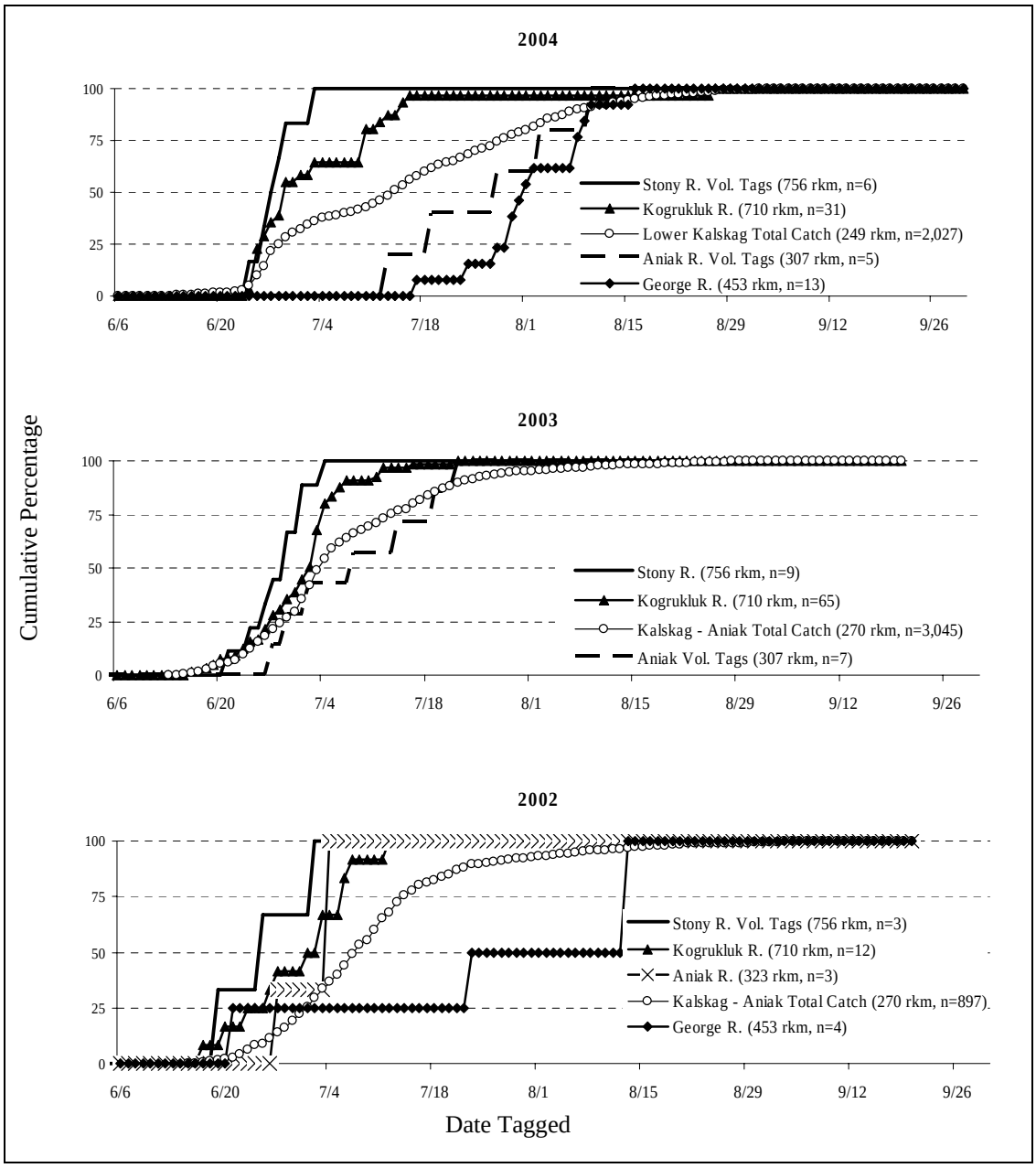


Figure 20.–Cumulative percentages of sockeye salmon tag recoveries (escapement projects and volunteers) by tag date, 2002–2004.

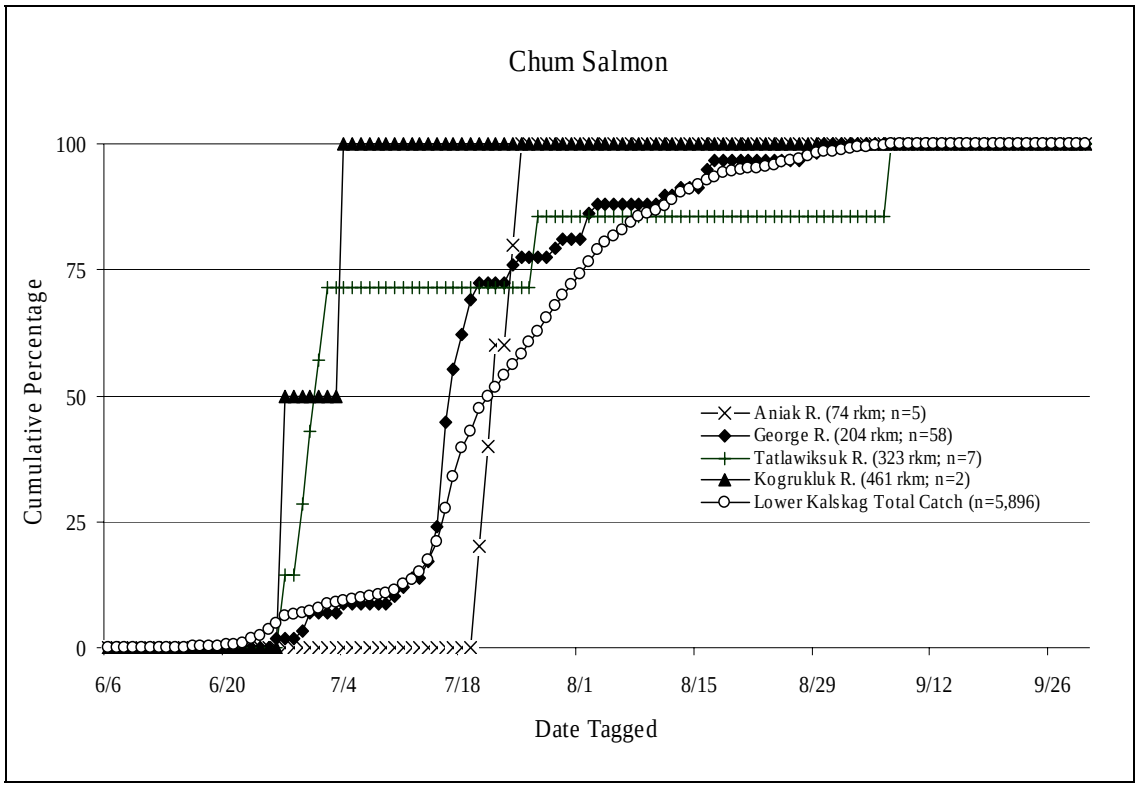


Figure 21.–Cumulative percentage of recaptured chum salmon at the Kogrukluk River weir, Tatlawiksuk River weir, George River weir, and the Aniak River sonar site by date of tagging, and of the total number of chum salmon captured at the Lower Kalskag tag site, Kuskokwim River, 2004.

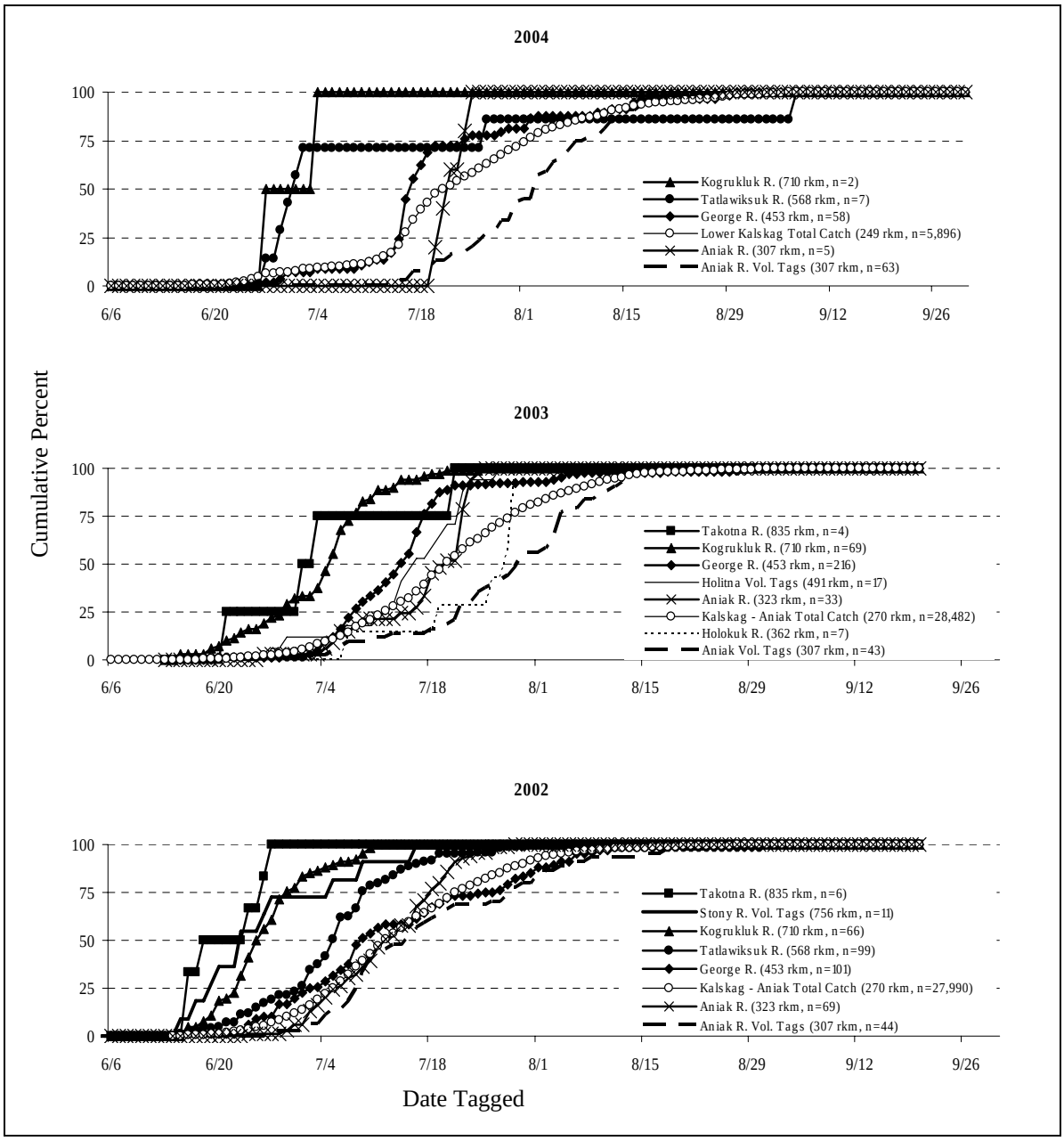


Figure 22.–Cumulative percentages of chum salmon tag recoveries (escapement projects and volunteers) by tag date, 2002–2004.

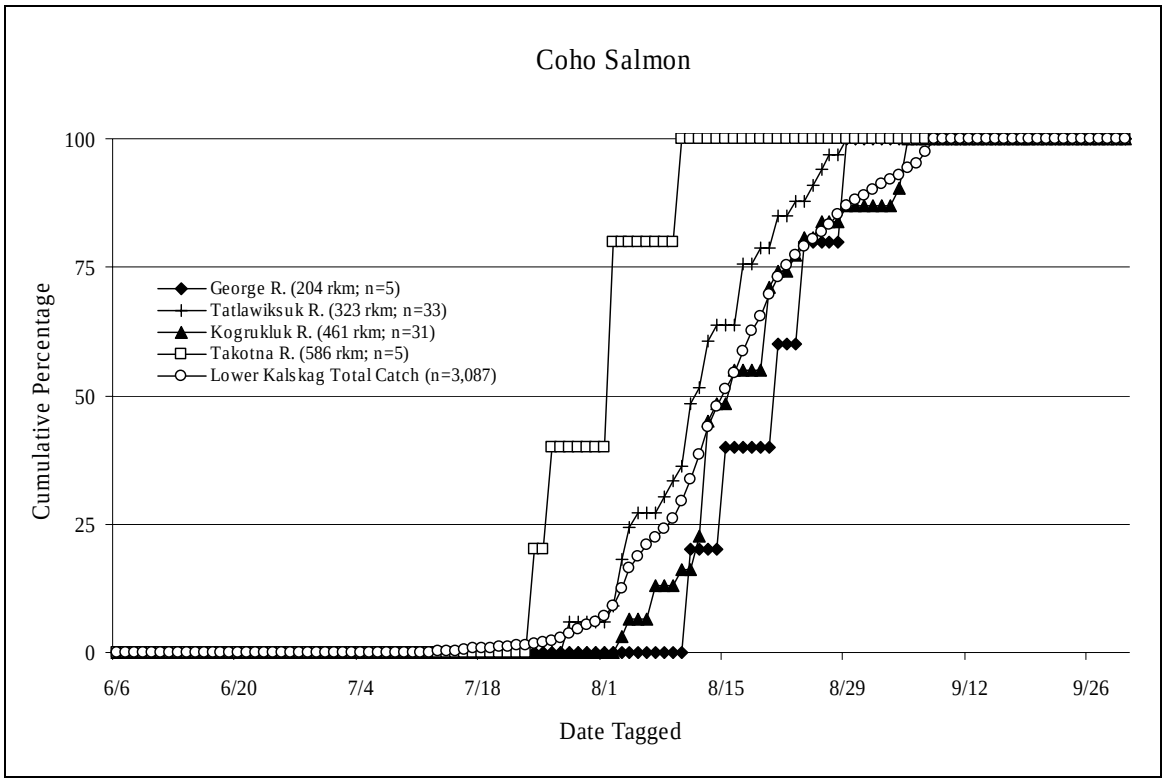


Figure 23.–Cumulative percentage of recaptured coho salmon at the Takotna River weir, Tatlawiksuk River weir, Kogrukluk River weir, and George River weir by date of tagging, and of the total number of coho salmon captured at the Lower Kalskag tag site, Kuskokwim River, 2004.

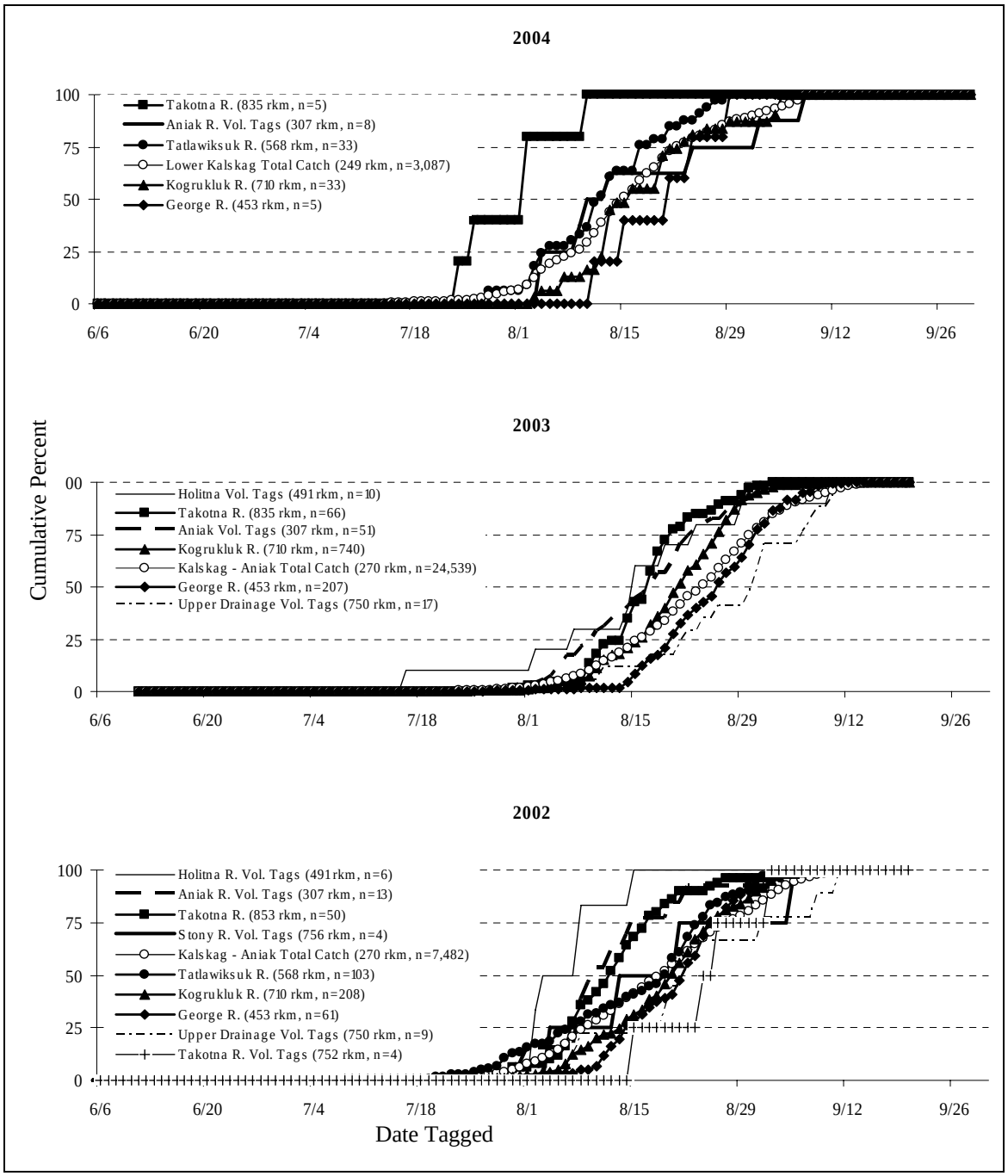


Figure 24.–Cumulative percentages of coho salmon tag recoveries (escapement projects and volunteers) by tag date, 2002–2004.

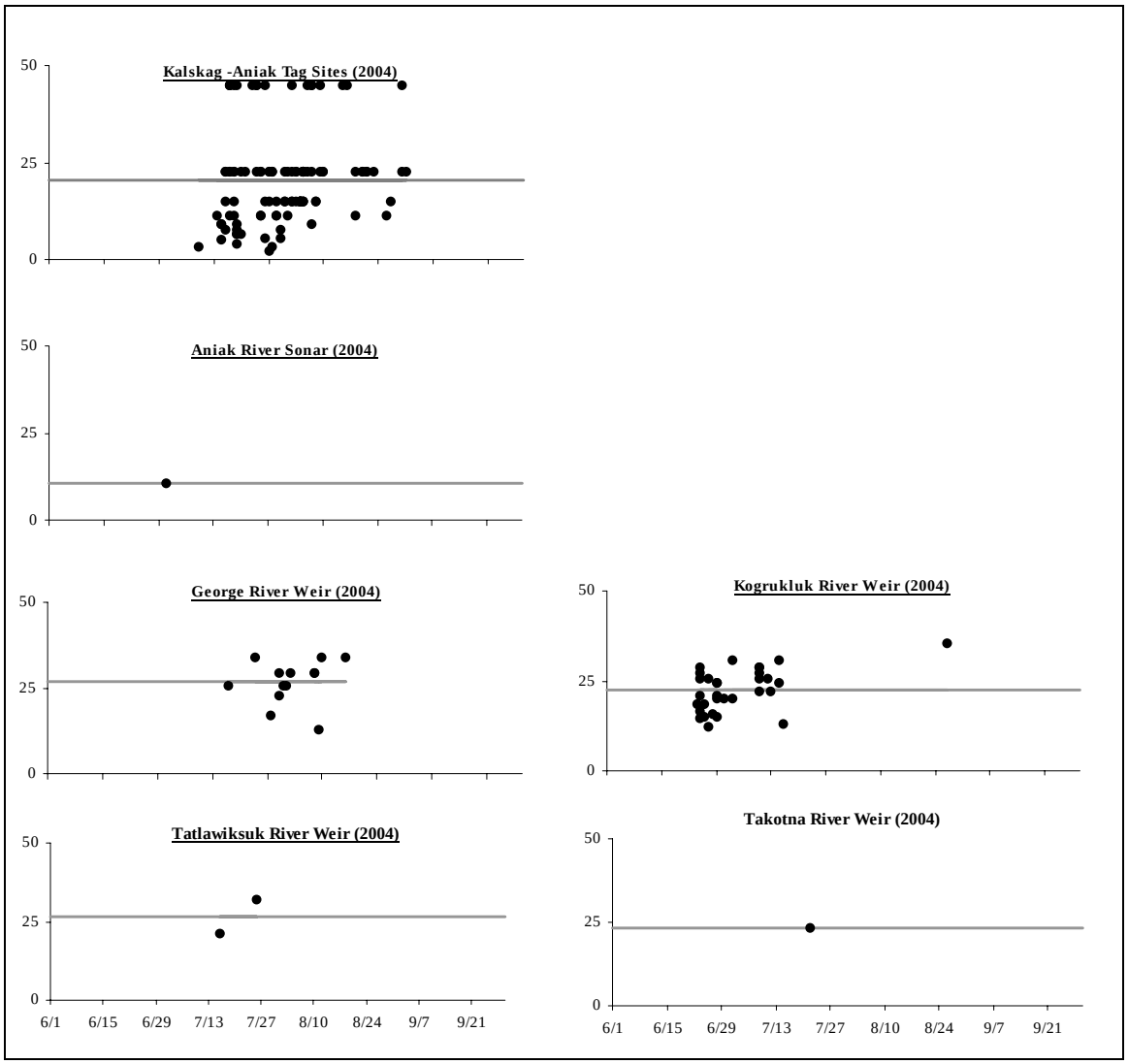


Figure 25.–Travel speed (rkm/day) of tagged sockeye salmon from the Lower sites to the Aniak sonar site and the George and Kogrukluk River weirs, Kuskokwim River, 2004.

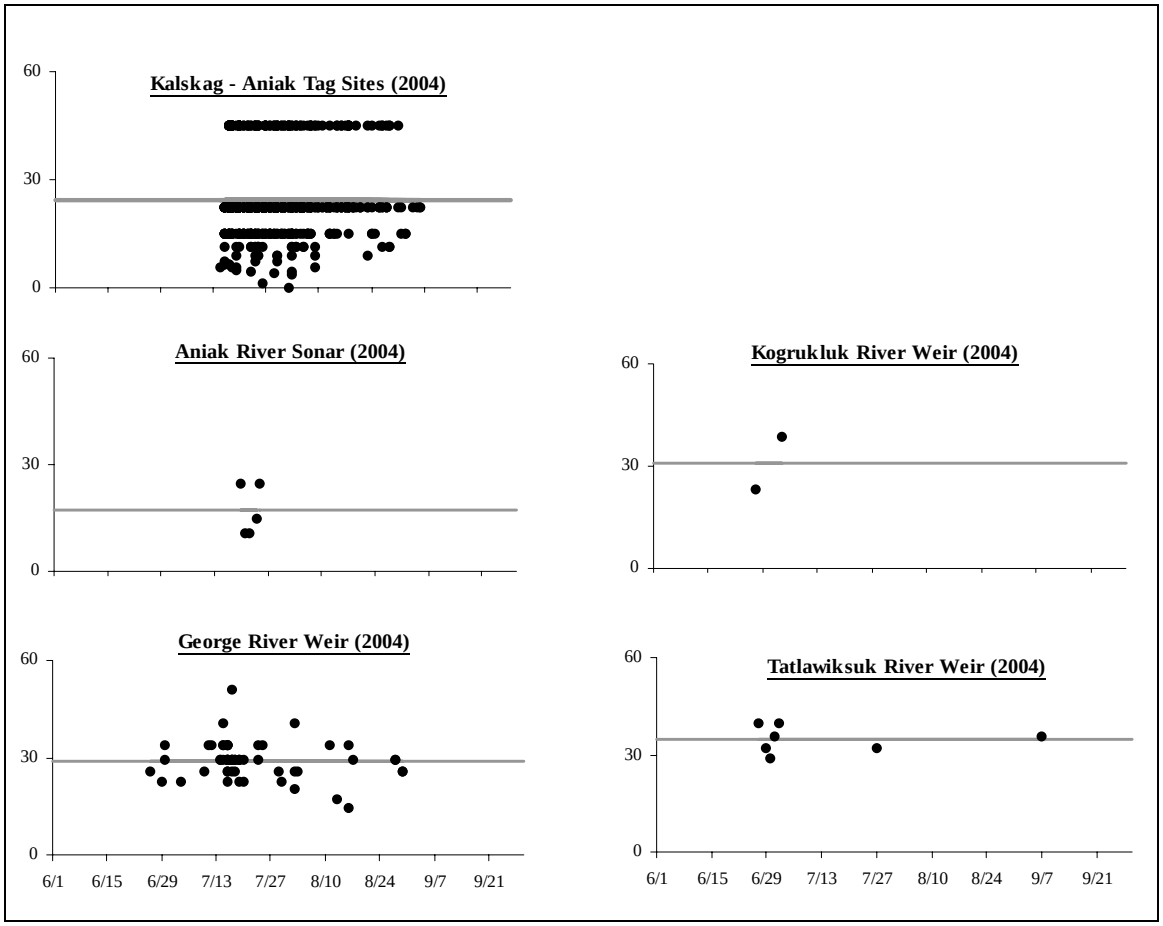


Figure 26.–Travel speed (rkm/day) of tagged chum salmon from the Lower Kalskag tag sites to the Aniak River sonar site and the George, Kogrukluk, and Takotna River weirs, Kuskokwim River, 2004.

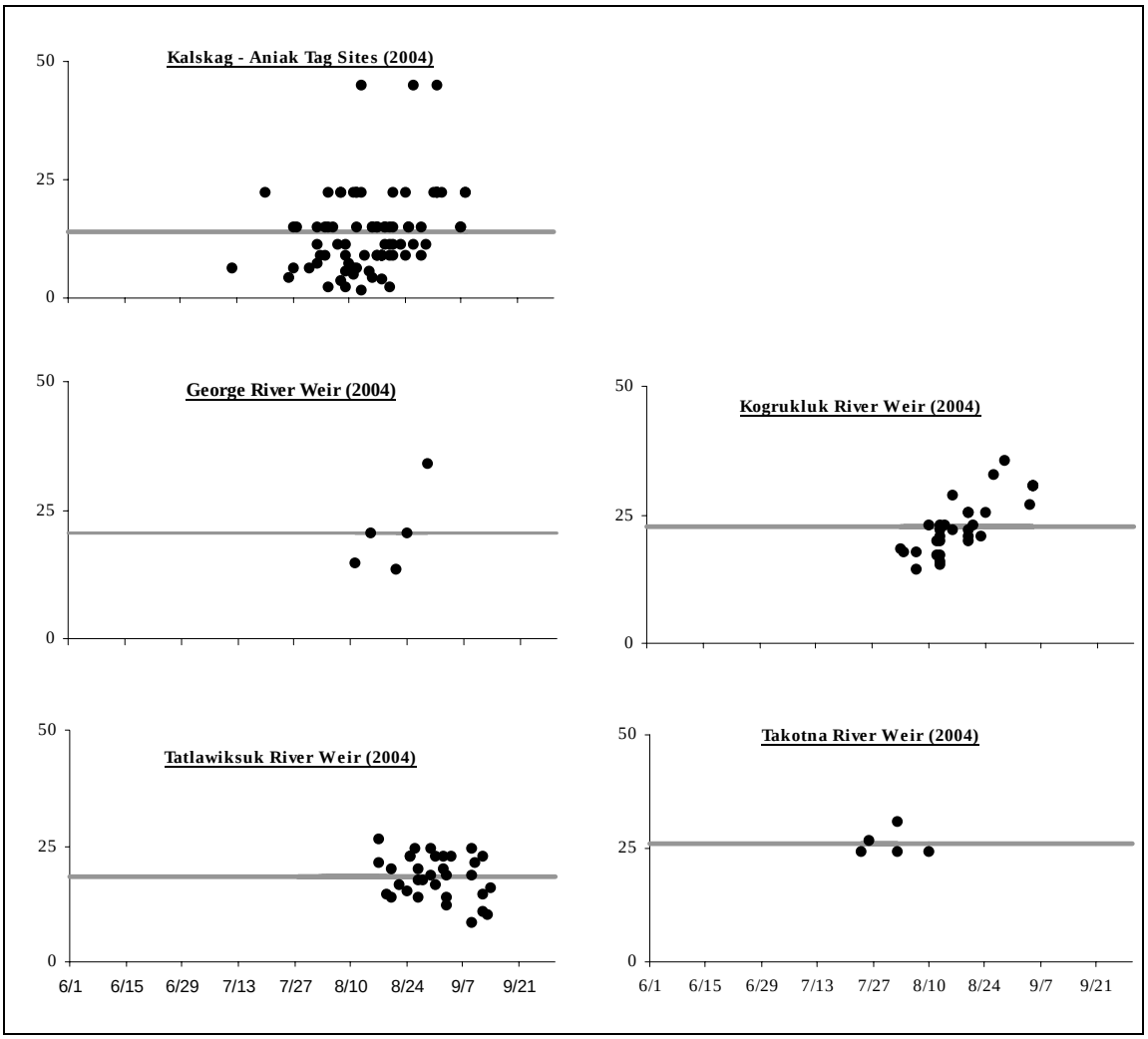


Figure 27.–Travel speed (rkm/day) of tagged coho salmon from the Lower Kalskag tag sites to the Aniak River sonar site and the George, Kogrukluk, and Takotna River weirs, Kuskokwim River, 2004.

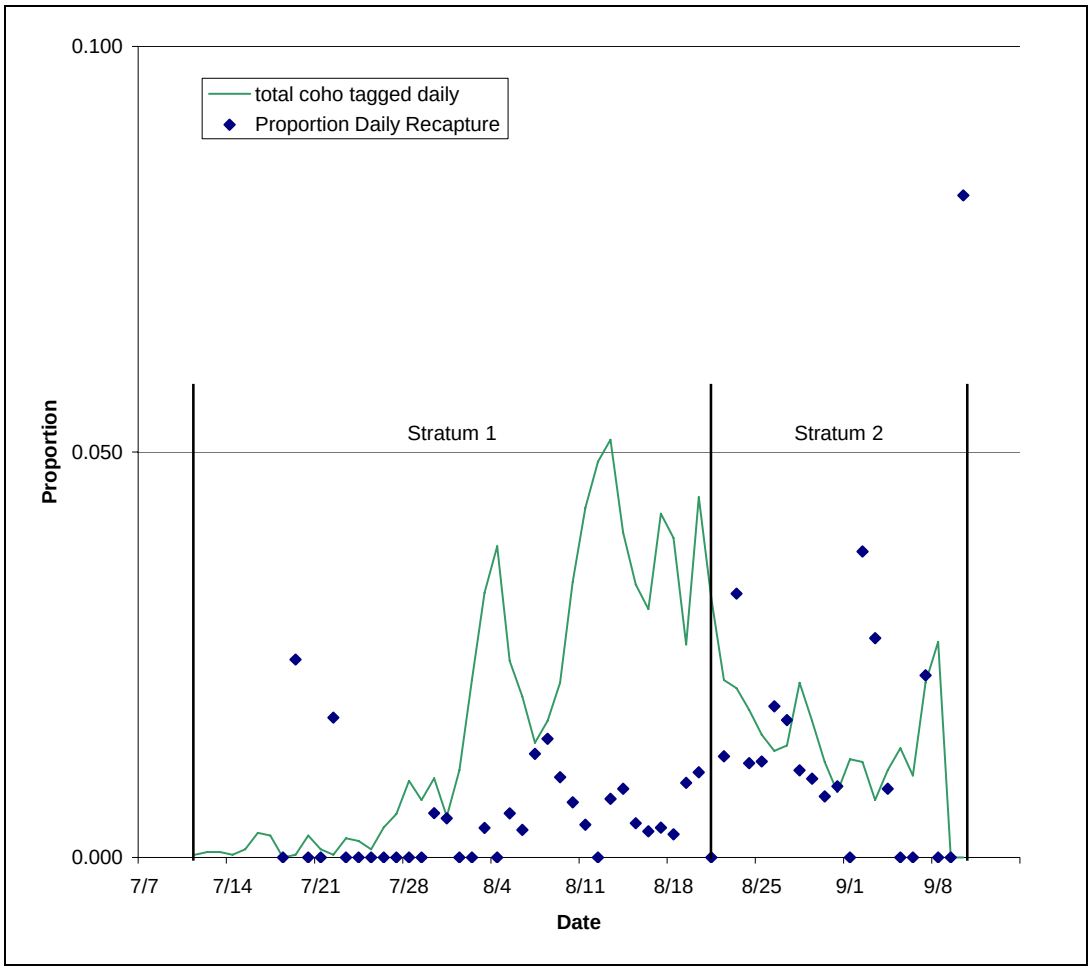


Figure 28.–Proportion of the total coho salmon tagged daily at the Lower Kalskag site compared to proportion of total daily recaptures at the Aniak site and strata used in estimating abundance of coho salmon upstream of Kalskag, Kuskokwim River, 2004.

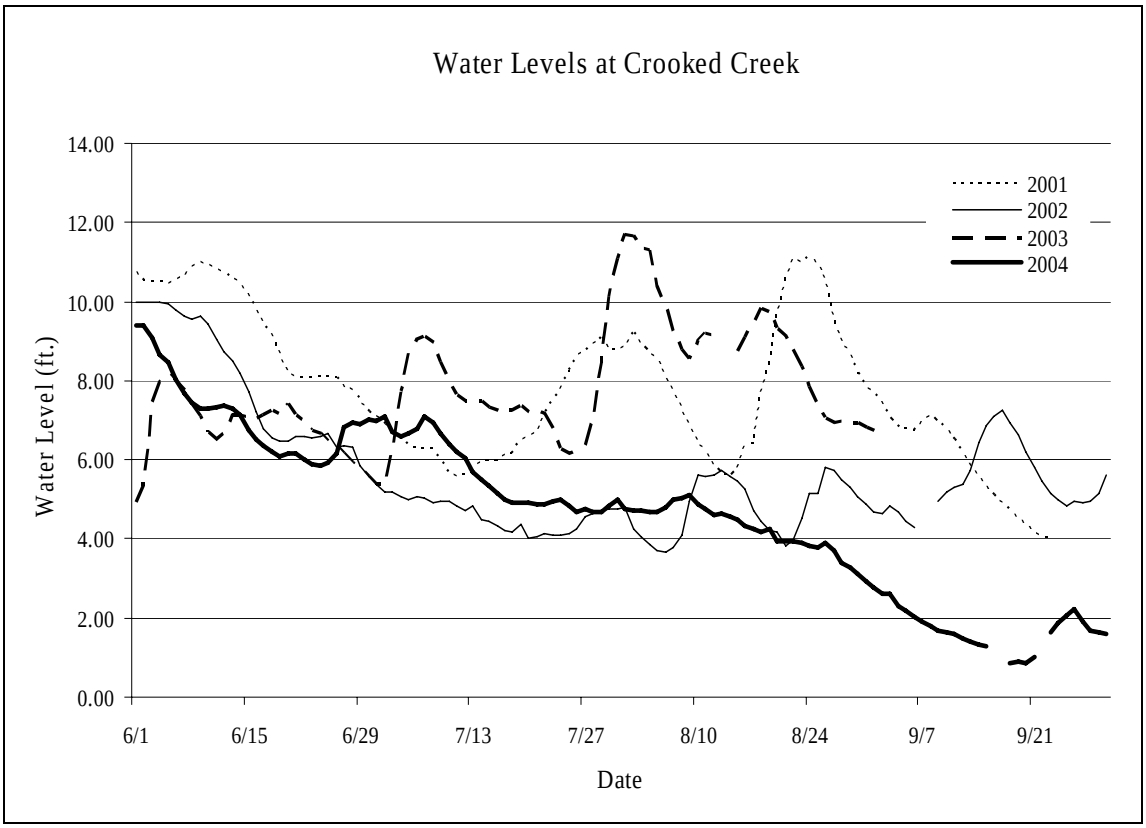


Figure 29.–Water levels at the Crooked Creek gauging station, mainstem Kuskokwim River, 2001–2004.

APPENDIX A

Appendix A1.–Daily summary of tagged, untagged, and recaptured sockeye salmon at the Lower Kalskag site, Kuskokwim River, 2004.

Lower Kalskag									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
6/07	0	0	0	0	0	0	0	0	0.0
6/08	0	0	0	0	0	0	0	0	0.0
6/09	0	1	0	0	0	0	0	1	0.0
6/10	2	0	0	0	0	0	0	2	0.1
6/11	1	0	0	0	0	0	0	1	0.2
6/12	0	1	0	0	0	0	0	1	0.2
6/13	0	0	0	0	0	0	0	0	0.2
6/14	3	1	0	0	0	0	0	4	0.4
6/15	4	1	0	0	0	0	0	5	0.7
6/16	3	1	0	0	0	0	0	4	0.9
6/17	5	0	1	0	0	0	1	7	1.2
6/18	5	0	1	0	0	0	0	6	1.5
6/19	5	0	0	0	0	0	0	5	1.8
6/20	6	0	1	0	0	0	0	7	2.1
6/20	0	0	0	0	0	0	0	0	2.1
6/22	4	1	0	0	0	0	0	5	2.4
6/23	12	3	0	1	0	0	0	16	3.2
6/24	15	21	1	2	0	0	0	39	5.1
6/25	74	30	1	2	0	0	0	107	10.4
6/26	49	35	0	0	0	0	0	84	14.5
6/27	54	72	13	13	0	0	0	152	22.0
6/28	37	22	0	1	0	0	2	62	25.1
6/29	58	8	0	0	0	0	3	69	28.5
6/30	38	7	1	0	0	0	0	46	30.7
7/01	26	8	1	0	0	0	0	35	32.5
7/02	35	11	0	0	0	0	1	47	34.8
7/03	26	9	0	0	0	0	0	35	36.5
7/04	19	6	2	0	0	0	1	28	37.9
7/05	13	3	1	0	0	0	0	17	38.7
7/06	8	1	0	0	0	0	0	9	39.2
7/07	15	3	0	0	0	0	0	18	40.1
7/08	4	5	1	0	0	0	0	10	40.6
7/09	11	7	0	1	0	0	1	20	41.5
7/10	11	12	0	0	0	0	0	23	42.7
7/11	18	17	1	0	0	0	0	36	44.4
7/12	16	13	2	2	0	0	2	35	46.2
7/13	30	21	0	0	0	0	0	51	48.7
7/14	23	24	1	0	0	0	1	49	51.1
7/15	21	28	0	2	0	0	1	52	53.7
7/16	23	26	0	0	0	0	4	53	56.3
7/17	19	15	0	0	0	0	0	34	58.0
7/18	23	18	0	1	0	0	3	45	60.2
7/19	16	17	0	0	0	0	2	35	61.9
7/20	24	6	0	0	0	0	0	30	63.4
7/21	13	6	0	0	0	0	1	20	64.4
7/22	3	7	0	2	0	0	1	13	65.0
7/23	19	11	1	1	0	0	3	35	66.7
7/24	17	15	0	0	0	0	2	34	68.4
7/25	13	14	0	0	0	0	3	30	69.9

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Appendix A1.–Page 2 of 2.

Lower Kalskag									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
7/26	13	13	0	0	0	0	2	28	71.3
7/27	13	10	1	0	0	0	0	24	72.5
7/28	18	20	1	0	0	0	2	41	74.5
7/29	18	12	4	0	0	0	3	37	76.3
7/30	15	12	0	0	0	0	3	30	77.8
7/31	11	6	0	0	0	0	2	19	78.7
8/01	16	5	0	0	0	0	2	23	79.9
8/02	28	6	1	0	0	0	2	37	81.7
8/03	24	7	0	0	0	0	2	33	83.3
8/04	25	11	2	1	0	0	2	41	85.3
8/05	10	8	0	1	0	0	1	20	86.3
8/06	7	13	0	0	0	2	2	24	87.5
8/07	17	8	0	0	0	0	3	28	88.9
8/08	19	2	1	0	0	0	1	23	90.0
8/09	9	3	0	0	0	0	0	12	90.6
8/10	10	4	0	0	0	0	1	15	91.4
8/11	5	7	0	1	0	0	1	14	92.1
8/12	3	4	0	0	0	0	0	7	92.4
8/13	12	5	0	0	0	0	0	17	93.2
8/14	12	1	0	0	0	0	1	14	93.9
8/15	2	4	0	0	0	0	1	7	94.3
8/16	5	5	0	0	0	0	0	10	94.8
8/17	9	6	0	0	0	0	0	15	95.5
8/18	8	2	0	0	0	1	1	12	96.1
8/19	4	4	0	0	0	0	0	8	96.5
8/20	7	1	0	0	0	0	0	8	96.9
8/21	3	3	0	0	0	0	1	7	97.2
8/22	2	1	0	0	0	0	0	3	97.4
8/23	2	2	0	0	0	0	0	4	97.6
8/24	6	2	0	0	0	0	0	8	98.0
8/25	1	2	0	0	0	0	1	4	98.2
8/26	5	0	1	0	0	0	0	6	98.5
8/27	1	4	0	0	0	0	1	6	98.8
8/28	8	1	0	0	0	0	0	9	99.2
8/29	2	2	0	0	0	0	0	4	99.4
8/30	2	3	0	0	0	0	0	5	99.7
8/31	1	0	0	0	0	0	0	1	99.7
9/01	0	0	0	0	0	0	0	0	99.7
9/02	1	0	0	0	1	0	0	2	99.8
9/03[d]	0	3	0	0	0	0	0	3	100.0
9/04[d]	0	0	0	0	0	0	0	0	100.0
9/05[d]	0	1	0	0	0	0	0	1	100.0
9/06[d]	0	0	0	0	0	0	0	0	100.0
9/07[d]	0	0	0	0	0	0	0	0	100.0
9/08[d]	0	0	0	0	0	0	0	0	100.0
Total	**1,175**	**710**	**40**	**31**	**1**	**3**	**67**	**2,027**	**100.0**

[a] Right bank fish wheel.

[b] Left bank fish wheel.

[c] Multiple recaptures included.

[d] Right bank fish wheel inoperable due to low water.

Appendix A2.–Daily summary of tagged, untagged, and recaptured sockeye salmon at the Aniak site, Kuskokwim River, 2004.

Aniak									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
7/18	0	0	2	53	0	0	6	61	5.8
7/19	0	0	10	39	0	0	4	53	10.8
7/20	0	0	11	51	0	0	5	67	17.2
7/21	0	0	14	29	0	0	2	45	21.5
7/22	0	0	7	34	0	0	3	44	25.7
7/23	0	0	5	40	0	0	2	47	30.1
7/24	0	0	13	43	0	0	3	59	35.7
7/25	0	0	10	44	0	0	3	57	41.2
7/26	0	0	7	26	0	0	3	36	44.6
7/27	0	0	3	32	0	0	4	39	48.3
7/28	0	0	7	21	0	0	0	28	51.0
7/29	0	0	5	36	0	2	5	48	55.5
7/30	0	0	5	18	0	0	5	28	58.2
7/31	0	0	2	22	0	0	0	24	60.5
8/01	0	0	3	14	0	0	1	18	62.2
8/02	0	0	6	13	0	0	3	22	64.3
8/03	0	0	4	19	0	0	5	28	66.9
8/04	0	0	2	14	0	0	1	17	68.5
8/05	0	0	2	25	0	0	6	33	71.7
8/06	0	0	4	20	0	1	2	27	74.2
8/07	0	0	4	41	0	0	15	60	79.9
8/08	0	0	3	17	0	0	6	26	82.4
8/09	0	0	1	13	0	0	1	15	83.8
8/10	0	0	1	10	0	0	2	13	85.1
8/11	0	0	3	19	0	0	3	25	87.5
8/12	0	0	3	19	0	0	3	25	89.8
8/13	0	0	1	7	0	0	0	8	90.6
8/14	0	0	2	7	0	0	0	9	91.4
8/15	0	0	0	2	0	0	0	2	91.6
8/16	0	0	1	2	0	0	1	4	92.0
8/17	0	0	2	4	0	0	1	7	92.7
8/18	0	0	1	4	0	0	1	6	93.3
8/19	0	0	0	2	0	0	0	2	93.4
8/20	0	0	0	3	0	0	1	4	93.8
8/21	0	0	0	7	0	0	0	7	94.5
8/22	0	0	3	8	0	0	3	14	95.8
8/23	0	0	1	7	0	0	2	10	96.8
8/24	0	0	0	3	0	0	0	3	97.1
8/25	0	0	1	2	0	0	1	4	97.4
8/26	0	0	1	4	0	0	0	5	97.9
8/27	0	0	0	0	0	0	0	0	97.9
8/28	0	0	1	2	0	0	0	3	98.2
8/29	0	0	1	1	0	0	0	2	98.4
8/30	0	0	0	1	0	0	2	3	98.7
8/31	0	0	0	1	0	0	1	2	98.9

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Appendix A2.–Page 2 of 2.

Aniak									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Cum. % Catch
9/01	0	0	1	1	0	0	1	3	99.1
90/2	0	0	0	0	0	0	1	1	99.2
9/03	0	0	1	1	0	0	0	2	99.4
9/04	0	0	0	2	0	0	0	2	99.6
9/05	0	0	0	2	0	0	0	2	99.8
9/06	0	0	0	0	0	0	0	0	99.8
9/07	0	0	0	0	0	0	0	0	99.8
9/08[d]	0	0	0	0	0	0	0	0	99.8
9/09[d]	0	0	0	0	0	0	0	0	99.8
9/10[d]	0	0	0	2	0	0	0	2	100.0
Total	**0**	**0**	**154**	**787**	**0**	**3**	**108**	**1,052**	**100.0**

[a] Right bank fish wheel.

[b] Left bank fish wheel.

[c] Multiple recaptures included.

[d] Right bank fish wheel inoperable (damaged).

APPENDIX B

Appendix B1.–Daily summary of tagged, untagged, and recaptured chum salmon at the Lower Kalskag site, Kuskokwim River, 2004.

Lower Kalskag									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
6/07	1	0	0	0	0	0	0	1	0.0
6/08	1	0	0	0	0	0	0	1	0.0
6/09	0	0	0	0	0	0	0	0	0.0
6/10	0	0	0	0	0	0	0	0	0.0
6/11	0	0	0	0	0	0	0	0	0.0
6/12	0	0	0	0	0	0	0	0	0.0
6/13	0	0	0	0	0	0	0	0	0.0
6/14	2	0	0	0	0	0	0	2	0.1
6/15	3	0	0	0	0	0	0	3	0.1
6/16	4	1	0	0	0	0	0	5	0.2
6/17	7	0	0	0	0	0	0	7	0.3
6/18	1	0	0	0	0	0	0	1	0.3
6/19	3	0	1	0	0	0	0	4	0.4
6/20	3	0	0	0	0	0	0	3	0.5
6/20	7	0	2	1	0	0	0	10	0.6
6/22	11	8	2	0	0	0	1	22	1.0
6/23	20	17	2	4	0	0	0	43	1.7
6/24	24	17	2	0	0	0	1	44	2.5
6/25	45	24	1	1	0	0	0	71	3.7
6/26	35	30	4	3	0	0	0	72	4.9
6/27	49	13	7	6	0	0	2	77	6.2
6/28	21	3	0	0	0	0	0	24	6.6
6/29	17	0	1	0	0	0	0	18	6.9
6/30	15	3	0	1	0	0	0	19	7.2
7/01	32	2	2	1	0	0	0	37	7.9
7/02	37	1	3	0	0	0	0	41	8.6
7/03	22	0	0	0	0	0	0	22	8.9
7/04	16	1	2	0	0	0	1	20	9.3
7/05	11	1	4	1	0	0	0	17	9.6
7/06	14	1	1	1	0	0	0	17	9.9
7/07	11	3	0	0	0	0	0	14	10.1
7/08	10	5	3	1	0	0	2	21	10.4
7/09	15	11	2	1	0	0	0	29	10.9
7/10	12	12	3	2	0	0	1	30	11.4
7/11	35	18	5	1	0	0	1	60	12.5
7/12	29	27	1	2	0	0	1	60	13.5
7/13	51	32	6	4	0	0	2	95	15.1
7/14	77	43	8	2	0	0	2	132	17.3
7/15	99	107	8	5	0	0	4	223	21.1
7/16	157	205	10	7	0	0	6	385	27.6
7/17	196	157	7	4	0	0	10	374	34.0
7/18	149	159	1	7	0	0	11	327	39.5
7/19	63	135	5	3	0	0	2	208	43.1
7/20	73	172	0	2	0	0	7	254	47.4
7/21	33	102	2	0	0	0	5	142	49.8
7/22	15	96	1	3	0	0	3	118	51.8
7/23	33	82	4	2	0	0	6	127	53.9
7/24	34	92	0	5	0	4	1	136	56.2
7/25	34	78	0	2	0	2	7	123	58.3

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Appendix B1.–Page 2 of 2.

Lower Kalskag									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
7/26	22	98	1	3	0	0	12	136	60.6
7/27	27	95	0	3	0	0	6	131	62.9
7/28	50	69	6	9	0	3	12	149	65.4
7/29	44	87	3	5	0	1	9	149	67.9
7/30	21	84	0	3	0	14	5	127	70.1
7/31	31	71	2	4	0	0	4	112	72.0
8/01	21	102	2	3	0	0	8	136	74.3
8/02	24	90	3	8	0	0	5	130	76.5
8/03	22	111	3	6	0	2	9	153	79.1
8/04	13	57	2	2	0	2	6	82	80.5
8/05	14	49	2	4	0	5	3	77	81.8
8/06	15	42	3	3	0	4	3	70	83.0
8/07	10	58	3	4	0	4	6	85	84.4
8/08	9	46	1	3	0	5	1	65	85.5
8/09	9	23	0	0	0	2	7	41	86.2
8/10	5	24	3	1	0	1	0	34	86.8
8/11	2	51	0	5	0	0	3	61	87.8
8/12	6	59	0	1	0	2	0	68	89.0
8/13	9	61	3	1	0	0	5	79	90.3
8/14	3	33	0	3	0	1	0	40	91.0
8/15	19	29	1	0	0	6	3	58	92.0
8/16	11	30	0	1	0	0	6	48	92.8
8/17	6	27	2	0	0	1	2	38	93.4
8/18	9	38	0	0	0	0	3	50	94.3
8/19	5	17	0	3	0	0	1	26	94.7
8/20	2	7	0	1	0	2	1	13	94.9
8/21	3	6	0	2	0	0	1	12	95.1
8/22	0	3	3	0	0	2	1	9	95.3
8/23	4	12	0	0	0	1	2	19	95.6
8/24	3	11	1	0	0	2	2	19	95.9
8/25	4	18	0	1	0	1	3	27	96.4
8/26	1	11	0	0	0	1	1	14	96.6
8/27	8	12	0	0	0	1	2	23	97.0
8/28	9	16	0	1	0	1	2	29	97.5
8/29	5	22	5	2	0	0	2	36	98.1
8/30	7	13	0	5	0	0	1	26	98.6
8/31	2	2	0	0	0	1	0	5	98.6
9/01	1	5	0	2	0	1	0	9	98.8
9/02	2	7	4	3	0	0	1	17	99.1
9/03[d]		8		4	0	0	0	12	99.3
9/04[d]		5		5	0	0	2	12	99.5
9/05[d]		9		3	0	0	0	12	99.7
9/06[d]		7		1	0	0	0	8	99.8
9/07[d]		6		1	0	0	0	7	99.9
9/08[d]		2		1	0	0	0	3	100.0
Total	**1,985**	**3,291**	**153**	**179**	**0**	**72**	**216**	**5,896**	**100.0**

[a] Right bank fish wheel.

[b] Left bank fish wheel.

[c] Multiple recaptures included.

[d] Right bank fish wheel inoperable due to low water.

Appendix B2.–Daily summary of tagged, untagged, and recaptured chum salmon at the Aniak site, Kuskokwim River, 2004.

Aniak									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
7/18	0	0	257	1,227	0	0	33	1,517	8.4
7/19	0	0	464	1,103	0	0	48	1,615	17.3
7/20	0	0	447	1,081	0	0	29	1,557	25.9
7/21	0	0	379	625	0	0	31	1,035	31.7
7/22	0	0	275	753	0	0	20	1,048	37.4
7/23	0	0	223	584	0	0	22	829	42.0
7/24	0	0	350	688	0	0	26	1,064	47.9
7/25	0	0	164	864	0	0	21	1,049	53.7
7/26	0	0	151	685	0	0	23	859	58.5
7/27	0	0	135	662	0	3	20	820	63.0
7/28	0	0	123	538	0	0	22	683	66.8
7/29	0	0	107	494	0	17	21	639	70.3
7/30	0	0	58	349	0	4	27	438	72.7
7/31	0	0	102	324	0	9	19	454	75.2
8/01	0	0	77	320	0	8	16	421	77.6
8/02	0	0	71	303	0	15	12	401	79.8
8/03	0	0	51	271	0	1	15	338	81.7
8/04	0	0	39	287	0	12	10	348	83.6
8/05	0	0	39	427	0	3	29	498	86.3
8/06	0	0	26	392	0	1	18	437	88.8
8/07	0	0	17	222	0	0	21	260	90.2
8/08	0	0	14	128	0	0	14	156	91.1
8/09	0	0	15	148	0	1	10	174	92.0
8/10	0	0	4	136	0	5	16	161	92.9
8/11	0	0	7	78	0	3	5	93	93.4
8/12	0	0	19	86	0	0	4	109	94.0
8/13	0	0	11	52	0	0	4	67	94.4
8/14	0	0	14	71	0	0	6	91	94.9
8/15	0	0	14	66	0	2	5	87	95.4
8/16	0	0	8	57	0	2	7	74	95.8
8/17	0	0	11	44	0	3	9	67	96.2
8/18	0	0	8	55	0	1	6	70	96.5
8/19	0	0	6	64	0	2	10	82	97.0
8/20	0	0	4	39	0	1	6	50	97.3
8/21	0	0	6	29	0	1	6	42	97.5
8/22	0	0	9	49	0	1	1	60	97.8
8/23	0	0	4	26	0	1	3	34	98.0
8/24	0	0	3	37	0	1	1	42	98.3
8/25	0	0	3	17	0	0	3	23	98.4
8/26	0	0	9	17	0	1	1	28	98.5
8/27	0	0	6	20	0	0	3	29	98.7
8/28	0	0	9	26	0	0	7	42	98.9
8/29	0	0	1	41	0	0	3	45	99.2
8/30	0	0	6	28	0	0	6	40	99.4
8/31	0	0	1	18	0	0	1	20	99.5

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Appendix B2.–Page 2 of 2.

Aniak									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
9/01	0	0	4	12	0	0	1	17	99.6
9/02	0	0	2	13	0	0	3	18	99.7
9/03	0	0	3	5	0	0	1	9	99.8
9/04	0	0	4	5	0	0	1	10	99.8
9/05	0	0	0	4	0	0	2	6	99.9
9/06	0	0	2	1	0	0	1	4	99.9
9/07	0	0	1	2	0	0	1	4	99.9
9/08[d]		0		6	0	0	2	8	99.9
9/09[d]		0		10	0	0	0	10	100.0
9/10[d]		0		1	0	0	0	1	100.0
Total	**0**	**0**	**3,763**	**13,590**	**0**	**98**	**632**	**18,083**	**100.0**

[a] Right bank fish wheel.

[b] Left bank fish wheel.

[c] Multiple recaptures included.

[d] Right bank fish wheel inoperable (damaged).

APPENDIX C

Appendix C1.–Daily summary of tagged, untagged, and recaptured coho salmon at the Lower Kalskag site, Kuskokwim River, 2004.

Lower Kalskag									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
7/01	0	0	0	0			0	0	0.0
7/02	0	0	0	0			0	0	0.0
7/03	0	0	0	0			0	0	0.0
7/04	0	0	0	0			0	0	0.0
7/05	0	0	0	0			0	0	0.0
7/06	0	0	0	0			0	0	0.0
7/07	0	0	0	0			0	0	0.0
7/08	0	0	0	0			0	0	0.0
7/09	0	0	0	0			0	0	0.0
7/10	0	0	0	0			0	0	0.0
7/11	0	1	0	0			0	1	0.0
7/12	2	0	0	0			0	2	0.1
7/13	1	1	0	0			0	2	0.2
7/14	1	0	0	0			0	1	0.2
7/15	1	2	0	0			0	3	0.3
7/16	6	3	0	0			0	9	0.6
7/17	7	1	0	0			0	8	0.8
7/18	0	0	1	0			0	1	0.9
7/19	1	0	0	0			0	1	0.9
7/20	5	3	0	0			0	8	1.2
7/21	2	1	0	0			0	3	1.3
7/22	0	1	0	0			0	1	1.3
7/23	4	3	0	0			0	7	1.5
7/24	3	2	0	0	1	0	2	8	1.8
7/25	2	1	0	0	0	0	0	3	1.9
7/26	5	6	0	0	0	0	0	11	2.2
7/27	10	6	0	0	0	0	0	16	2.8
7/28	10	13	1	2	5	0	0	31	3.8
7/29	13	8	1	0	0	0	1	23	4.5
7/30	15	11	0	0	3	0	0	29	5.4
7/31	8	7	0	0	0	0	0	15	5.9
8/01	15	15	0	0	2	0	1	33	7.0
8/02	39	26	1	0	0	0	0	66	9.1
8/03	51	40	2	2	6	0	0	101	12.4
8/04	67	39	2	0	8	0	4	120	16.3
8/05	35	23	1	1	14	1	3	78	18.8
8/06	16	19	2	0	24	0	1	62	20.8
8/07	16	11	0	1	15	0	1	44	22.2
8/08	29	10	0	1	11	1	2	54	24.0
8/09	24	23	0	0	17	0	0	64	26.1
8/10	49	29	1	1	23	0	0	103	29.4
8/11	81	37	0	0	10	0	2	130	33.6
8/12	97	21	4	0	27	4	0	153	38.6
8/13	113	35	1	0	5	9	2	165	43.9
8/14	67	13	4	0	39	0	2	125	47.9
8/15	50	13	1	2	37	0	1	104	51.3

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Appendix C1.–Page 2 of 2.

Lower Kalskag									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
8/16	51	20	3	1	20	1	2	98	54.5
8/17	59	15	3	1	52	0	2	132	58.8
8/18	56	35	2	0	26	0	0	119	62.6
8/19	43	35	2	1	0	0	2	83	65.3
8/20	83	28	3	0	21	0	1	136	69.7
8/21	56	34	1	1	5	0	5	102	73.0
8/22	26	20	0	0	19	0	3	68	75.2
8/23	24	24	0	0	14	0	0	62	77.2
8/24	14	19	0	0	21	0	0	54	79.0
8/25	4	25	0	0	16	1	2	48	80.5
8/26	13	6	1	1	20	0	0	41	81.8
8/27	17	6	1	0	18	0	0	42	83.2
8/28	27	4	0	0	33	0	1	65	85.3
8/29	21	9	0	0	20	0	2	52	87.0
8/30	20	11	0	0	4	0	1	36	88.2
8/31	6	7	0	0	11	0	0	24	88.9
9/01	10	17	0	0	9	0	2	38	90.2
9/02	5	21	0	0	9	0	0	35	91.3
9/03[d]		8		0	13	0	0	21	92.0
9/04[d]		15		0	17	1	0	33	93.0
9/05[d]		22		0	18	0	0	40	94.3
9/06[d]		21		0	9	0	0	30	95.3
9/07[d]		52		0	12	0	0	64	97.4
9/08[d]		72		0	7	0	2	81	100.0
Total	**1,380**	**950**	**38**	**15**	**641**	**18**	**47**	**3,089**	**100.0**

[a] Right bank fish wheel.

[b] Left bank fish wheel.

[c] Multiple recaptures included.

[d] Right bank fish wheel inoperable due to low water.

Appendix C2.–Daily summary of tagged, untagged, and recaptured coho salmon at the Aniak site, Kuskokwim River, 2004.

Aniak									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Cum. % Catch
7/18	0	0	5	21			0	26	0.2
7/19	0	0	14	26			1	41	0.6
7/20	0	0	23	17			0	40	1.0
7/21	0	0	17	13			0	30	1.3
7/22	0	0	29	28			1	58	1.8
7/23	0	0	46	20			0	66	2.5
7/24	0	0	50	27			0	77	3.2
7/25	0	0	50	30			0	80	4.0
7/26	0	0	46	40	0	1	0	87	4.8
7/27	0	0	62	66	0	1	0	129	6.0
7/28	0	0	10	79	0	0	0	179	7.7
7/29	0	0	85	82	0	9	0	176	9.4
7/30	0	0	10	77	0	4	1	183	11.1
7/31	0	0	12	67	0	14	1	207	13.1
8/01	0	0	11	68	0	9	0	188	14.9
8/02	0	0	12	55	0	22	0	201	16.8
8/03	0	0	21	56	0	3	1	275	19.4
8/04	0	0	24	77	0	29	0	354	22.7
8/05	0	0	19	159	0	12	2	368	26.2
8/06	0	0	14	135	0	14	1	294	29.0
8/07	0	0	13	95	0	0	3	235	31.2
8/08	0	0	10	79	0	17	3	205	33.2
8/09	0	0	79	106	0	15	2	202	35.1
8/10	0	0	14	110	0	41	2	294	37.9
8/11	0	0	70	68	0	108	1	247	40.2
8/12	0	0	26	155	0	1	0	417	44.2
8/13	0	0	15	106	0	15	2	277	46.8
8/14	0	0	31	130	0	24	4	473	51.3
8/15	0	0	28	154	0	31	2	475	55.8
8/16	0	0	16	113	0	32	1	310	58.7
8/17	0	0	15	92	0	22	1	273	61.3
8/18	0	0	18	159	0	12	1	352	64.7
8/19	0	0	23	178	0	22	4	435	68.8
8/20	0	0	14	199	0	31	4	381	72.4
8/21	0	0	61	55	0	27	0	143	73.8
8/22	0	0	14	154	0	14	4	321	76.8
8/23	0	0	12	85	0	33	8	246	79.1
8/24	0	0	13	107	0	17	3	258	81.6
8/25	0	0	10	54	0	5	2	169	83.2
8/26	0	0	66	78	0	14	3	161	84.7
8/27	0	0	10	52	0	21	3	177	86.4
8/28	0	0	10	49	0	27	2	186	88.2
8/29	0	0	11	80	0	14	2	206	90.1
8/30	0	0	51	81	0	0	1	133	91.4
8/31	0	0	42	52	0	19	1	114	92.5

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Appendix C2.–Page 2 of 2.

Aniak									
	Capture Gear								
	Fish Wheel				Gillnet				
	Tagged		Untagged						Cum. %
Date	RB[a]	LB[b]	RB[a]	LB[b]	Tagged	Untagged	Recaps[c]	Total	Catch
9/01	0	0	72	32	0	10	0	114	93.5
9/02	0	0	69	29	0	4	4	106	94.5
9/03	0	0	59	42	0	7	3	111	95.6
9/04	0	0	66	43	0	8	1	118	96.7
9/05	0	0	20	16	0	0	0	36	97.1
9/06	0	0	32	8	0	0	0	40	97.4
9/07	0	0	43	32	0	12	2	89	98.3
9/08[d]		0		45	0	0	0	45	98.7
9/09[d]		0		73	0	14	0	87	99.5
9/10[d]		0		41	0	4	4	49	100.0
Total	**0**	**0**	**5,629**	**4,095**	**0**	**739**	**81**	**10,544**	**100.0**

[a] Right bank fish wheel.

[b] Left bank fish wheel.

[c] Multiple recaptures included.

[d] Right bank fish wheel inoperable (damaged).

APPENDIX D

Appendix D1.–Tags observed and recovered by date, Aniak River sonar site, 2004.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
22-Jun			
23-Jun			
24-Jun			
25-Jun			
26-Jun			
27-Jun			
28-Jun			
29-Jun			
30-Jun			
1-Jul			
2-Jul			
3-Jul			
4-Jul			
5-Jul			
6-Jul			
7-Jul			
8-Jul		1	
9-Jul			
10-Jul			
11-Jul			
12-Jul			
13-Jul			
14-Jul			
15-Jul			
16-Jul			
17-Jul			
18-Jul			
19-Jul			
20-Jul			
21-Jul			
22-Jul			
23-Jul	1		
24-Jul			
25-Jul			
26-Jul			
27-Jul			
28-Jul	2		
29-Jul	2		
30-Jul			
31-Jul			
1-Aug			
2-Aug			
3-Aug			
4-Aug			
5-Aug			
6-Aug			
7-Aug			
8-Aug			
9-Aug			
10-Aug			
11-Aug			
12-Aug			
13-Aug			

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Appendix D1.–Page 2 of 2.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
14-Aug			
15-Aug			
16-Aug			
17-Aug			
18-Aug			
19-Aug			
20-Aug			
21-Aug			
22-Aug			
23-Aug			
24-Aug			
25-Aug			
26-Aug			
27-Aug			
28-Aug			
29-Aug			
30-Aug			
31-Aug			
1-Sep			
2-Sep			
3-Sep			
4-Sep			
5-Sep			
6-Sep			
7-Sep			
8-Sep			
9-Sep			
10-Sep			
11-Sep			
12-Sep			
13-Sep			
14-Sep			
15-Sep			
16-Sep			
17-Sep			
18-Sep			
19-Sep			
20-Sep			
21-Sep			
22-Sep			
23-Sep			
24-Sep			
Total Tags	5	1	0
Passed:	5	1	0

Appendix D2.–Tags observed and recovered by date, George River weir, 2004.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
22-Jun			
23-Jun			
24-Jun			
25-Jun			
26-Jun			
27-Jun			
28-Jun			
29-Jun			
30-Jun			
1-Jul			
2-Jul			
3-Jul			
4-Jul	1		
5-Jul			
6-Jul	1(1)		
7-Jul	1		
8-Jul	1		
9-Jul			
10-Jul			
11-Jul			
12-Jul			
13-Jul	1		
14-Jul			
15-Jul			
16-Jul			
17-Jul	1		
18-Jul	2		
19-Jul			
20-Jul	1		
21-Jul	5(1)		
22-Jul	5		
23-Jul	5		
24-Jul	6		
25-Jul	5	1	
26-Jul	4		
27-Jul	1		
28-Jul	1		
29-Jul	1		
30-Jul	1	1	
31-Jul	2		
1-Aug			
2-Aug			
3-Aug			
4-Aug			
5-Aug			
6-Aug	1	1	
7-Aug	1		
8-Aug	1	2	
9-Aug		3	
10-Aug	1		
11-Aug	1		
12-Aug	1		
13-Aug			

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Appendix D2.–Page 2 of 2.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
14-Aug			
15-Aug		2	
16-Aug		1	
17-Aug	1		
18-Aug			
19-Aug			
20-Aug			
21-Aug			
22-Aug	1	1	
23-Aug			
24-Aug	1		
25-Aug	1	1	2
26-Aug			
27-Aug			
28-Aug			
29-Aug			
30-Aug	1	(1)	(2)
31-Aug	(2)		(5)
1-Sep			(3)
2-Sep			(3)
3-Sep			1(1)
4-Sep	1		1(1)
5-Sep			1
6-Sep			
7-Sep	1		(1)
8-Sep			
9-Sep			
10-Sep			
11-Sep			
12-Sep			
13-Sep			
14-Sep			
15-Sep			
16-Sep			
17-Sep			
18-Sep			
19-Sep			
20-Sep			
21-Sep			
22-Sep			
23-Sep			
24-Sep			
Total Tags	58(4)	13(1)	5(16)
Passed:	62	14	21

Appendix D3.–Tags observed and recovered by date, Tatlawiksuk River weir, 2004.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
22-Jun			
23-Jun			
24-Jun			
25-Jun			
26-Jun			
27-Jun			
28-Jun			
29-Jun			
30-Jun			
1-Jul	(1)		
2-Jul			
3-Jul			
4-Jul			
5-Jul	1		
6-Jul			
7-Jul			
8-Jul			
9-Jul	1		
10-Jul	2		
11-Jul	1		
12-Jul			
13-Jul			
14-Jul			
15-Jul			
16-Jul			
17-Jul			
18-Jul			
19-Jul			
20-Jul			
21-Jul			
22-Jul			
23-Jul			
24-Jul			
25-Jul			
26-Jul			
27-Jul			
28-Jul			
29-Jul			
30-Jul			
31-Jul		1	
1-Aug			
2-Aug			
3-Aug			
4-Aug			
5-Aug		1	
6-Aug	1		
7-Aug			
8-Aug			
9-Aug			
10-Aug		(1)	
11-Aug			
12-Aug			
13-Aug			

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Appendix D3.–Page 2 of 2.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
14-Aug			
15-Aug			
16-Aug			
17-Aug			2
18-Aug			
19-Aug			1
20-Aug			2
21-Aug			
22-Aug			1
23-Aug			
24-Aug			1
25-Aug			2
26-Aug			1(1)
27-Aug			3
28-Aug			1
29-Aug			
30-Aug			2
31-Aug			2
1-Sep			
2-Sep			2
3-Sep			3
4-Sep			1
5-Sep			
6-Sep			
7-Sep			
8-Sep			
9-Sep			3
10-Sep			1
11-Sep			
12-Sep			3
13-Sep			1
14-Sep			1(1)
15-Sep			
16-Sep	1		
17-Sep			
18-Sep			
19-Sep			
20-Sep			
21-Sep			
22-Sep			
23-Sep			
24-Sep			
Total Tags	7(1)	2(1)	33(2)
Passed:	8	3	35

Appendix D4.–Tags observed and recovered by date, Kogrukluk River weir, 2004.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
22-Jun			
23-Jun			
24-Jun			
25-Jun			
26-Jun			
27-Jun			
28-Jun			
29-Jun			
30-Jun			
1-Jul			
2-Jul			
3-Jul			
4-Jul			
5-Jul			
6-Jul			
7-Jul			
8-Jul			
9-Jul			
10-Jul			
11-Jul		1	
12-Jul		1	
13-Jul		1	
14-Jul			
15-Jul		1	
16-Jul	1		
17-Jul	1	1	
18-Jul		3	
19-Jul		1	
20-Jul			
21-Jul		2(1)	
22-Jul		1	
23-Jul		2	
24-Jul		1	
25-Jul			
26-Jul		3(1)	
27-Jul		4 [a]	
28-Jul		1	
29-Jul			
30-Jul		3	
31-Jul		1	
1-Aug			
2-Aug			
3-Aug		2	
4-Aug		1	
5-Aug			
6-Aug			
7-Aug			
8-Aug			
9-Aug			
10-Aug			
11-Aug			
12-Aug			
13-Aug			

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Appendix D4.–Page 2 of 2.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
14-Aug			
15-Aug			(1)
16-Aug	(1)		
17-Aug			
18-Aug			(1)
19-Aug			(1)
20-Aug		1	
21-Aug			(1)
22-Aug			(2)
23-Aug			(3)
24-Aug			
25-Aug			
26-Aug			(1)
27-Aug			
28-Aug			1
29-Aug			
30-Aug			2
31-Aug			
1-Sep			1
2-Sep			2
3-Sep			2
4-Sep			2
5-Sep			1
6-Sep			1
7-Sep			2
8-Sep			2
9-Sep		1	2
10-Sep			2
11-Sep			4
12-Sep			2 (1)
13-Sep			
14-Sep			1
15-Sep			
16-Sep			(1)
17-Sep			(1)
18-Sep			(1)
19-Sep			(5)
20-Sep			3
21-Sep			1 (2)
22-Sep			(2)
23-Sep			
24-Sep			
Total Tags	2 (1)	31 (2)	31 (23)
Passed:	3	33	54

[a] One additional tag was recovered from a carcass on the weir; date of passage is unknown.

Appendix D5.–Tags observed and recovered by date, Takotna River weir, 2004.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
22-Jun			
23-Jun			
24-Jun			
25-Jun			
26-Jun			
27-Jun			
28-Jun			
29-Jun			
30-Jun			
1-Jul			
2-Jul			
3-Jul			
4-Jul			
5-Jul			
6-Jul			
7-Jul			
8-Jul			
9-Jul			
10-Jul			
11-Jul			
12-Jul			
13-Jul			
14-Jul			
15-Jul			
16-Jul			
17-Jul			
18-Jul			
19-Jul			
20-Jul			
21-Jul			
22-Jul			
23-Jul			
24-Jul			
25-Jul			
26-Jul			
27-Jul			
28-Jul			
29-Jul			
30-Jul			
31-Jul			
1-Aug			
2-Aug			
3-Aug			
4-Aug			
5-Aug			
6-Aug			
7-Aug			
8-Aug			
9-Aug			
10-Aug			
11-Aug			
12-Aug			
13-Aug			

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Appendix D5.–Page 2 of 2.

	Kuskokwim River Tagging Project		
	Chum	Sockeye	Coho
Date	Tags Recovered (Observed)	Tags Recovered (Observed)	Tags Recovered (Observed)
14-Aug			
15-Aug			
16-Aug		1	
17-Aug			2
18-Aug			
19-Aug			
20-Aug			
21-Aug			1
22-Aug			
23-Aug			
24-Aug			
25-Aug			
26-Aug			1
27-Aug			
28-Aug			
29-Aug			
30-Aug			
31-Aug			
1-Sep			
2-Sep			
3-Sep			1
4-Sep			
5-Sep			
6-Sep			
7-Sep			
8-Sep			
9-Sep			
10-Sep			
11-Sep			
12-Sep			
13-Sep			
14-Sep			
15-Sep			
16-Sep			
17-Sep			
18-Sep			
19-Sep			
20-Sep			
21-Sep			
22-Sep			
23-Sep			
24-Sep			
Total Tags	0	1	5
Passed:	0	1	5

APPENDIX E

Appendix E1.–Number of recovered tags from sockeye salmon by subsistence, commercial, and sport fishing, at locations downstream and upstream from the Lower Kalskag tagging site, Kuskokwim River, 2004.

Community	Fishery Type				
Downstream	**Subsistence**	**Commercial**	**Sport**	**Found**	**Grand Total**
Quinhagak	1	0	0	0	1
Johnson R.	4	0	1	0	5
Napakiak	1	1	0	0	2
Oscarville	1	0	0	0	1
Bethel	2	4	1	0	7
Akiak	5	1	0	0	6
Akiachak	9	6	0	0	15
Kwethluk	4	0	1	0	5
Gweek R.	0	1	0	0	1
Tuluksak	5	0	0	0	5
Total	32	13	3	0	48
Near FW Sites					
Lower Kalskag	9	0	0	0	9
Aniak	3	0	0	0	3
Total	12	0	0	0	12
Upstream					
Aniak R.	1	0	1	4	6
Sleetmute	2	0	1	0	3
Red Devil	1	0	0	0	1
Holitna	9	0	0	0	9
Stony River	8	1	0	4	13
Total	21	1	2	8	32
Unknown					
Total	0	0	0	0	0
Combined					
Total	65	14	5	8	92

APPENDIX F

Appendix F1.–Number of recovered tags from chum salmon by subsistence, commercial, and sport fishers at locations downstream and upstream from the Lower Kalskag tag site, Kuskokwim River, 2004.

Community	Fishery Type				
Downstream	**Subsistence**	**Commercial**	**Sport**	**Found**	**Grand Total**
Johnson R.	2	0	0	0	2
Napakiak	2	1	0	0	3
Bethel	2	4	0	0	6
Akiak	10	1	0	0	11
Akiachak	7	6	0	0	13
Kasiguluk R.	1	0	0	0	1
Gweek R.	1	0	0	0	1
Tuluksak	3	1	0	0	4
Total	28	13	0	0	41
Near FW Sites					
Lower Kalskag	16	0	0	2	18
Aniak	8	0	2	2	12
Total	24	0	2	4	30
Upstream					
Aniak R.	2	0	1	60	63
Holokuk R.	1	0	0	1	2
Napaimiut	1	0	0	0	1
Crooked Creek	2	0	0	0	2
Red Devil	1	0	0	0	1
Stony River	1	0	0	0	1
Total	8	0	1	61	70
Unknown					
Total	0	0	0	0	0
Combined					
Total	60	13	3	65	141

APPENDIX G

Appendix G1.–Number of recovered tags from coho salmon by subsistence, commercial, and sport fishers at locations downstream and upstream from the Lower Kalskag tag sites, Kuskokwim River, 2004.

Community	Fishery Type				
Downstream	**Subsistence**	**Commercial**	**Sport**	**Found**	**Grand Total**
Tuntutuliak	0	1	0	0	1
Johnson R.	2	1	0	0	3
Fowler Island	0	1	0	0	1
Bethel	2	13	0	0	15
Akiak	2	0	0	0	2
Akiachak	1	5	0	0	6
Kwethluk	1	2	0	0	3
Gweek	1	0	0	0	1
Tuluksak	3	1	0	1	5
Total	12	24	0	1	37
Near Tag Sites					
Lower Kalskag	21	0	0	0	21
Aniak	9	0	11	1	21
Total	30	0	11	1	42
Upstream					
Aniak	2	0	13	4	19
Chuathbuluk	1	0	0	0	1
Crooked Creek	3	0	0	0	3
Holitna	0	0	1	0	1
Stony River	2	0	0	0	2
Total	8	0	14	4	26
Unknown					
Total	0	0	0	0	0
Combined					
Total	50	24	25	6	105